CHAPTER 3

MATERIALS AND METHODS

3.1 Introduction

Among the various health and hygiene products in used the disposable sanitary napkins have gained special importance. Due to upliftment of women education across the globe and the increased awareness of personnel hygiene, demand of the sanitary napkin is increasing every year. The present study has been undertaken to develop sanitary napkins with optimising various parameters of materials for its overall performance improvement.

Sanitary napkin is made up of different components comprising of various textiles and other functional materials. The functional characteristics of the components are: (i) Fluid acquisition layer: a material that is designed to quickly and efficiently absorb liquid; (ii) Distribution component: a part that evenly distributes the absorbed liquid throughout the product; (iii) Absorbent structure: a structure that is capable of absorbing and retaining liquid; (iv) Liquid impervious membrane: a barrier that prevents liquid from passing through to protect the garments. The various materials that are utilised to make various components of sanitary napkins are nonwoven textiles, wood pulp, plastic film, paper sheet, SAP powder etc. The layers of the napkin are designated as Top sheet, Acquisition Distribution Layer (ADL), Absorbent layer and Back sheet. The details of the various specifications of these materials are given in the Section 3.2.

These materials are converted in to sanitary napkins using commercial machines in the industries; the manufacturing details of the machines and processes have been described in Section 3.3. For the experimental study of comparative analysis of various characteristics, numbers of the sanitary napkin sample were prepared. The constructional details of these napkins have been given in Section 3.4. Methods and instruments used in measurements and testing of important properties of the samples have been discussed in Section 3.5.

3.2 Materials

The ideally the sanitary napkin should fit well and ensure the comfort to women against the discharge of blood from the uterine cavity during the physiological process of menstruation, for about three to seven days. Hence there is need to change the napkin frequently as each napkin has limited capacity to hold the liquid without leak. For the required functional performance the napkin is so designed to absorb the fluid from the body surface and transfer it to the inner core quickly and also provide the barrier by the outer layer for protection to underwear and other garments from wetting. These adverse requirements from a single product need a complex design of the napkin. Therefore generally a composite layered textile structure has been used in most such products made of about 3 to 4 different layers of specific materials.

Therefore the selection of various materials have been made considering the properties of moisture content of fibre, mass density, thickness, air permeability and water permeability of the textile structure which governs the absorbency; type of polymer, tensile properties of nonwovens etc. governing the stability of the final product.

3.2.1 Top Sheet

Top sheet is one of the important components of the sanitary napkin; its outer surface comes in direct contact with the body of skin of the user. The functional requirements of the top sheet are to acquire fluid released by the body but should feel dry, and should not adhere to the body, for a prolonged period. Therefore the fluid should be absorbed by the absorbent structure quickly to keep the surface dry. In this way, it reduces the chance of leaking. Thus the top sheet is the initial layer of the sanitary napkin designed to swiftly absorb fluids from the body and transfer to underneath layers. For this purpose generally a thick nonwoven of suitable polymer is ideal for the top sheet.

The materials for the top sheet selected are various synthetic spun-bond, single perforated and double perforated plastic films, laminated sheet (of PE+PP nonwoven), organic cotton spun-lace nonwoven, silk non-woven, and corn PLA nonwoven top sheet. Total of 8 different nonwoven top sheets have been selected for the study. Table 3.1 encompass the general specifications of fabric type, polymer type and method of manufacture used for the top sheet. These materials have been procured from various manufacturers and suppliers. The details of these top sheet materials also have been described in brief.

Table 3.1 Specifications of polymer, fabric and manufacture method used for top sheets

Sr. No.	Top sheet material	Polymer type	Method of manufacture
1	PP Spun-bond nonwoven	Polypropylene	Thermally sealed spun-bonded nonwoven
2	PP Hot air through nonwoven	Polypropylene	Hot air thermally bonded nonwoven
3	PE Single perforated poly-film	Polyethylene	Cast film extrusion
4	PE Double perforated poly-film	Polyethylene	Cast film extrusion
5	PE:PP Laminated composite	Polyethylene and polypropylene	Thermally laminated PE with PP nonwoven
6	Organic cotton nonwoven	Cotton	Spun-laced nonwoven
7	Mulberry silk nonwoven	Silk	Spun-laced nonwoven
8	Corn- PLA nonwoven	Polylactic Acid	Spun-laced nonwoven

(a) Spun-bond Nonwoven: Spun-laid nonwoven, also known as spun-bond nonwovens produced by a continuous manufacturing process in which the fibre are predominantly spun and subsequently dispersed into a sheet using deflectors. This method of nonwoven manufacture has ability to achieve very high belt speeds, resulting in to low-cost products. The uppermost very thin layer consists of hydrophilic absorbent fibres along with the hydrophobic layer (Fig 3.1(a), Fig. 3.1(b)). The spunbond nonwoven top sheet has been procured from Spunweb Nonwoven Pvt ltd, Morbi, India.

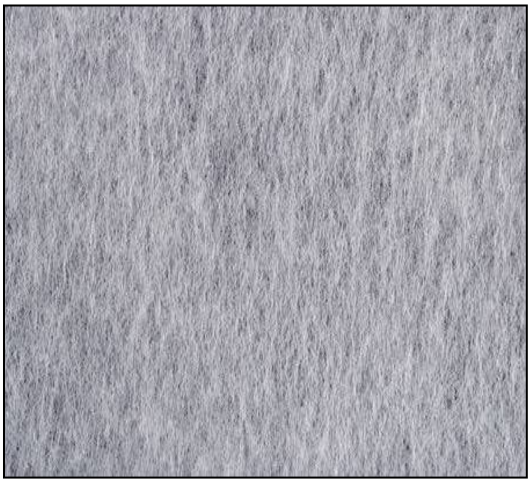


Fig. 3.1 (a) Hydrophobic nonwoven (b) Hydrophilic nonwoven

- **Spunbond hydrophobic material:** The hydrophobic qualities of Polypropylene Spunbond nonwoven material are exceptional, as it demonstrates little absorption and extraordinary resistance to water infiltration. Hydrophobic nonwovens are employed in the manufacturing of products designed to establish a moisture-resistant barrier and endure exposure to wet conditions.

- **Spunbond hydrophilic material:** A hydrophilic material possesses the ability to attract and retain water. Hydrophilic materials are used to make fabric that can absorb liquid and moisture, while still retaining their original strength and structure. Surfactants, specifically wetting agents are applied to convert a hydrophobic nature into a hydrophilic such as in case of polypropylene.

(b) Hot-air Through Nonwoven: Hot air-through nonwoven fabric is made utilising air-through-bonding technique used for synthetic polymeric fibres. This is a type of nonwoven fabric frequently referred to as Hot Air Cotton in the health and hygiene industries made normally entirely using Polypropylene. In the air bonding technique, hot air currents pass through the fibre web perpendicular to the plane resulting in to thermally binding the fibres with each other under the pressure to form the nonwoven fabric (Fig. 3.2). Unlike spun-bonded nonwovens this fabric is better in handle, softness, and bulkiness. It provides a notable degree of consistency in various characteristics such as, air permeability, filtration and tensile strength. These nonwovens are used to meet the specific quality requirements such as absorbency, stability and comfort for infant diapers, adult incontinent and various feminine hygiene products. The hot air through nonwoven fabric has been procured from Ace Nonwoven Pvt. Ltd; INDIA.

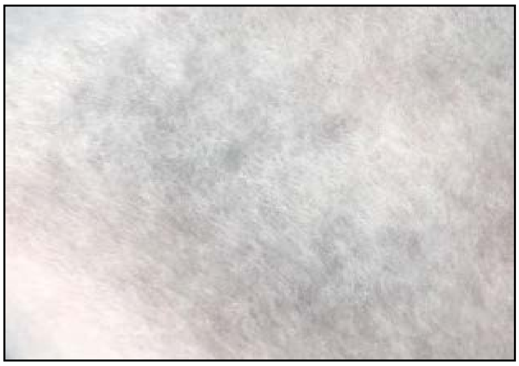


Fig. 3.2 Hot air through nonwoven

(c) **Single Perforated Poly-film:** Polyethylene films, are a type of plastic film commonly used in the manufacturing of hygiene products such disposable diapers, sanitary napkins, and adult incontinence products. These films provide an efficient moisture barrier that efficiently prevents any leakage, ensuring the wearer's dryness and comfort. PE films are typically produced by cast film extrusion using either high-density polyethylene (HDPE) or low-density polyethylene (LDPE) resin. The resins undergo a transformation into a thin film using either a blown film or cast film procedure. The resulting film is then adhered to other materials, such as nonwoven textiles, to create a composite structure that provides the necessary strength, flexibility, and absorbency for the specific use in hygiene goods. The single perforated poly top sheet has been procured from Tredegar Corporation, USA (Fig.3.3).

(d) **Double Perforated Poly-film:** Double perforated, or micro-perforated polymer film, is also manufactured by cast film extrusion using polyethylene. The molten resin is forced out through a die and subsequently formed into a film. The film is then punctured using a vacuum. The film can be perforated having perforations in several shapes, including circular, square, pentagonal, elliptical etc. The product possesses a lightweight construction and is specifically engineered to optimise absorption by facilitating the effortless entry of liquids into the absorbent core. Nevertheless, it inhibits the retrograde or outward movement of fluid. It is mostly used as the outermost layer of sanitary napkins and panty liners. The upper layer is composed of a hydrophilic film that has a three-dimensional structure and contains several apertures that are connected to an absorbent core. This design offers enhanced comfort and moisture-wicking properties, maintaining a neat and dry appearance. The double perforated poly top sheet also has been procured from Tredegar Corporation, USA (Fig. 3.4).

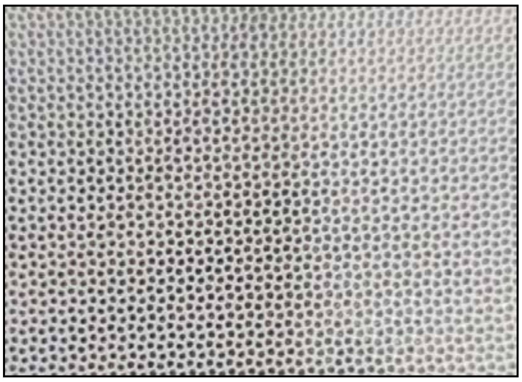


Fig. 3.3 Single-perforated film

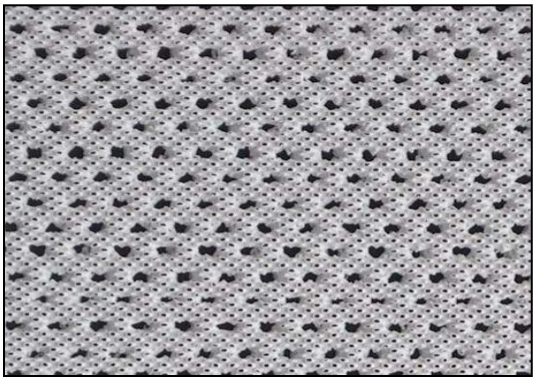


Fig. 3.4 Double-perforated film

(e) Laminated Composite: PE laminated non-woven fabric refers to a nonwoven fabric that has been coated with a layer of plastic film. Typically, the plastic is heated to its melting temperature, and applied onto the nonwoven fabric the cooled down to room temperature coating the surface forming the laminated fabric. The process of lamination involves bonding two or three layers of fabrics together to create the final product that stronger and possess better barrier properties due to increased resistance to alcohol, blood, hydrostatic pressure etc. The laminated poly top sheet has been procured from Tredegar Corporation, USA (Fig. 3.5).

(f) Organic Cotton Nonwoven: The organic cotton nonwoven is a sustainable and eco-friendly choice for personal hygiene applications. The fabric is made exclusively from unbleached organic cotton fibres using spun-lace process of nonwoven manufacturing leading to the presence of smooth fibre fringe spots on the fabric's surface. The Organic cotton top sheet has been procured from Welspun Pvt Ltd, India (Fig. 3.6).

(g) Mulberry Silk Nonwoven: The mulberry silk spun-lace nonwoven fabric possesses excellent moisture absorption and air permeability. It also has a soft handle, high strength, super draping properties, and does not require adhesive reinforcement. Therefore these fabrics have potential for use in high-quality skincare fabrics, medical dressings, as well as disposable hygiene goods like band-aids, and cosmetic applications. These fabrics excel in terms of safety, comfort, and usefulness.

It is important to note that the spun-lace web can be merged with any other fibre to create a composite product. The blend of silk with other fibres offers economically favourable cost-performance ratio.

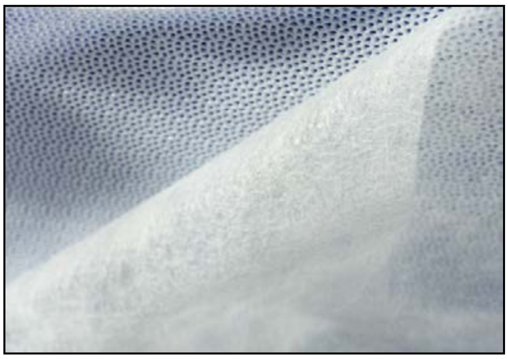


Fig. 3.5 Laminated perforated composite

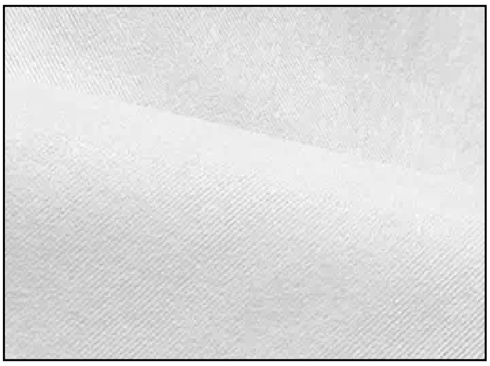


Fig. 3.6 Organic cotton nonwoven

The addition of natural silk mixed to cellulose fibres, which are routinely employed in the sanitary products, results in a blend that exhibits exceptional performance characteristics. The Silk-Nonwoven top sheet has been procured from Changshu Jinyu fibre Products Factory, China (Fig.3.7).

(h) Corn PLA Nonwoven: Polylactic acid (PLA), referred to as corn fibre used in spun-laced nonwoven possesses exceptional characteristics such as outstanding drape, slide, moisture absorption, and breathability. It exhibits natural bacteriostatic and weak acidity, which provide relief to the skin. Additionally, PLA fibre demonstrates good heat resistance and UV resistance. The production process does not use any chemical raw materials derived from petroleum. Additionally, the waste generated can be broken down in to carbon dioxide and water by microorganisms in soil and sea water. This decomposition process does not cause any pollution to the global environment.

PLA fibre is derived from natural and renewable plant resources, aligning with the sustainable development standards of the global society. This material amalgamates the benefits of synthetic fibres and natural fibres, while possessing a wholly natural circulatory system and energy. The Corn PLA-nonwoven has been procured from Winiw nonwoven materials Co. Ltd, China (Fig.3.8).

Fig. 3.7 Mulberry silk nonwoven

Fig. 3.8 Corn-PLA nonwoven

3.2.2 Acquisition Distribution Layer (ADL)

Next to the top sheet, second component of the sanitary napkin is the distribution component, which distributes the fluid, especially in the longitudinal direction; thereby enhance the spreading of fluid across the layer resulting in to higher fluid retention. The primary feature of sanitary pads is their ability to collect bodily fluids and hold them for an extended duration, while also preventing any reverse flow when subjected to pressure. The absorbent structure refers to this feature. It forms a hollow area having low density below the topmost layer to maintain dryness of the skin and enables rapid absorption of fluids to reduce the occurrence of leaks. For this study three different types of materials of acquisition distribution layer have been selected viz. polypropylene hot air-through nonwoven, a biodegradable PLA spun-lace nonwoven and tissue paper (Table 3.2).

(a) **Polypropylene Hot-air Through Nonwoven**: Hydrophilic Polypropylene nonwoven specifically designed for acquisition layers, facilitating rapid liquid absorption into the absorbent core. This fabric has a porous structure that allows liquids to disperse and be absorbed quickly into the core substance. These fabrics are used in manufacture of diapers, pads, adult incontinence products, sanitary napkins etc. They have a buffering capacity that creates a protective barrier between the moist inner layer and the outer skin, so improving the efficiency of rehydration. The PP hot air through nonwoven sheet has been procured from Ace Nonwoven Private Limited, India. (Fig. 3.9).

(b) **Corn-PLA Spun-lace Nonwoven:** The corn-PLA spun-laced nonwoven is similar to type of that described in Sec. 3.2.1 (h). It is made from PLA by blowing hot air through a nonwoven process. As this material is biodegradable nonwoven, it has been used as ADL sheet. This fabric has been procured from Shalag Industries Ltd; Israel (Fig. 3.10).

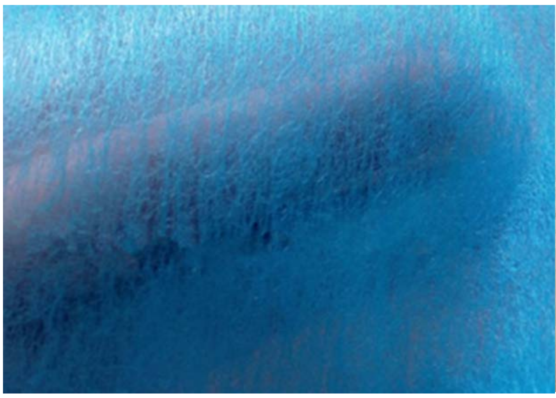


Fig. 3.9 PP hot air through nonwoven

Fig. 3.10 Corn-PLA hot air through nonwoven

Table 3.2 Specifications of various types of acquisition distribution layer (ADL)

Sr. No.	Type of ADL	Polymer type	Manufacture method	ADL code
1	PP Hot-air through nonwoven	Polypropylene	Hot air thermally bonding	DL_1
2	PLA Hot-air through nonwoven	Corn Poly-Lactic Acid	Hot air thermally bonding	DL_2
3	Tissue paper	Cellulose	Wet laid paper manufacture	DL_3

(c) Tissue Paper/non-woven: The use of tissue paper creates a low density void space beneath the top sheet to keep skin dry and enables rapid fluid absorption to help minimise leaks. Tissue paper wrapping is an essential component of sanitary napkin. It serves as a medium for the pad and helps reduce the occurrence of pin holes that can emerge during the compression process. Tissue paper used for wrapping has an outstanding capacity to absorb liquids. It provides protective barrier for the inner plastic material, safeguarding it from the superabsorbent particles.

The release paper, commonly referred to as the wrapper, that comes with sanitary napkins can be utilised as a protective covering for the pad after it has been used. The function of the wrapper is to enclose the soiled pad before it is discarded. Some low-cost sanitary napkins are equipped with a release paper that provides limited coverage. Tissue paper sheet has been procured from Pudumjee Paper Products, India. It has mass density of 16 g/m^2, and having plain pattern and white colour (Fig. 3.11).

Fig. 3.11 Tissue paper

3.2.3 Absorbent Core Layer

The absorbent core layer of sanitary pad typically consists of cellulose wood pulp; however there have been modifications in its composition. The commercially available products are being made by mixing Super Absorbent Polymer (SAP) with the pulp through an air laying process in order to enhance its absorbent properties. It is thus expected that it provides better absorption characteristics and stops any leakage of fluid already absorbed.

For the absorbent core layer, some sanitary products use different materials such as bamboo pulp fibres. The thickness of the absorbent layer is based on the predicted flow rate. For the absorbent core layer more than one material can be combined such as SAP powder, pine wood pulp fluff, SAP tissue paper, air laid (pulp) paper, corn starch powder, and bamboo pulp (Table 3.3). The various characteristics of these materials have been described in brief.

(a) **SAP Powder:** The superabsorbent powder is synthetic polymer substance is generally in the shape of little beads or granules. Upon contact with a liquid, these beads undergo swelling and transform into a gelatinous material which is good in absorption and retention of significant quantities of liquid. Sodium polyacrylate is the predominant raw ingredient utilized in personal care products for its exceptional absorbent properties. It is a hydrophilic material capable of absorbing water at a ratio of 300:1 by weight. Consequently, it is an ideal substance for incorporation into sanitary napkins and adult diapers, as they necessitate the capacity to absorb substantial quantities of liquid. Superabsorbent polymer powder (SAP) been procured from LG Chem, South Korea (Fig. 3.12).

Fig. 3.12 Superabsorbent polymer powder

(b) Pine Wood-pulp Fluff: Cellulose commonly referred to as wood pulp fluff, functions as absorbent heart of the napkin, responsible for collecting liquids resulting in to excellent absorbency characteristics of sanitary. The pulp has characteristics such as a high ratio of fibre to mass, reduced hardness, and shorter fibre length. In addition, it exhibits a uniform and consistent structure composed of short fibres. Typically wood pulp fluff in a napkin absorb approximately 10 cubic centimetres of water per gram of pulp, without any external force. Nevertheless, under a pressure of 5 kilopascals, the volume of the object reduces to about 2 cubic centimetres. Hence, incorporation of a super absorbent polymer is important to effectively retain liquids under pressure. The pine wood pulp fluff has been procured from GP Cellulose-Georgia-Pacific, Georgia, USA (Fig. 3.13).

(c) SAP Tissue Paper: Superabsorbent polymers in sanitary pads are present in the form of SAP paper. The superabsorbent polymer is coated onto a tissue or paper, which is subsequently inserted into the absorbent SAP sheet has been procured rom Cliniva Hygiene India Industries, Morbi, India (Fig. 3.14).

(d) Air-laid (pulp) Sheet: Air-laid paper is a type of material is produced using fluff pulp, exhibits greater bulk, porosity, and softness in comparison to conventional wet-laid paper and tissue. It has excellent water absorption characteristics and possesses significantly greater strength in comparison to regular tissue.

Fig. 3.13 Pine wood fluff pulp

Fig. 3.14 SAP- Tissue paper

Airlaid nonwoven is a manufacturing technique that creates a web using short fibres, often derived from softwood pulp. Fluff pulp is the primary fibre utilized in the production of airlaid nonwovens, although other natural and synthetic fibres can also be employed. The airlaid process was initially devised as a technique for producing paper without the need for water. The technique results in the production of a fabric that resembles paper, but is thicker, softer, and has a higher capacity for absorption compared to traditional paper. The Airlaid (fluff pulp) paper has been procured from Fiesta, China (Fig.3.15).

Bamboo Pulp Sheet: Cultivated bamboo undergoes processes to produce bamboo pulp. Bamboo and its fibres are a renewable and eco-friendly material suitable for incorporation in conventional tissue and hygiene products. One significant determinant of sustainability is the rapid growth rate of bamboo, which surpasses that of all other plants on Earth.As a point of comparison, bamboo plants typically achieve maturity within a span of 3 to 5 years, whereas other trees normally utilized for pulp production require 15 to 20 years to attain maturity. Due to its nature as a lignified plant of the grass family, bamboo does not require replanting following its harvest but resume its growth as a result of its rhizome structures. It is crucial to regulate the production process of the wood pulp, in order to minimize its environmental impact. The bamboo pulp sheet has been procured from Lotus Pulp Mills, Tamil Nadu; India (Fig. 3.16).

Fig. 3.15 Air laid wood pulp sheet

Fig. 3.16 Air laid bamboo pulp sheet

Table 3.3 Specifications of various types of materials for Absorbent Core Layers (ACL)

Sr. No.	Core layer Material	Polymer type	Manufacture method	Core layer Code
1	SAP powder	Sodium polyacrylate	Polymerisation	AC_1
2	Pine wood pulp fluff	Cellulose	Pulp manufacture	
3	SAP paper (SAP powder +wood pulp)	Sodium polyacrylate + cellulose	Wet laid paper manufacture	AC_2
4	Pine pulp fluff air-laid nonwoven	Cellulose	Hot-air thermally bonded nonwoven	
5	Corn starch sheet (Biodegradable)	Corn starch	Corn starch manufacture	AC_3
6	Bamboo pulp air-laid nonwoven	Cellulose	Hot-air thermally bonded nonwoven	

(e) Corn Starch Sheet: Corn starch is a kind of white, flavourless and odourless powder which is useful in papermaking, and processing foods and oral medicinal items. It is treated as a lubricant in surgical glove designing. The structure of the starch includes several functional properties such as swelling power, starch solubility, gelatinization, retro gradation, syneresis, and rheological behaviour. The chemical components in cornflour are Amylose and Amylopectin. The corn starch and water are heated to increase the granule size of the starch and solidify into gel or paste (Fig. 3.17). Corn starch base absorption sheet has been procured from Cliniva Hygiene India Industries, Morbi, India (Fig. 3.18).

These materials have been used in suitable combinations to form the Absorbent Core layers. Three different core layers have been formed for the sample preparation viz. AC_1, AC_2 and AC_3. Specifications of these core layers have given in Table 3.3.

Fig. 3.17 Corn starch powder

Fig. 3.18 Corn starch sheet

3.2.4 Back Sheet

A sheet that is impermeable to fluids and is often made of polyethylene, the back sheet serves the purpose of preventing leakage. The liquid barrier layer is the last layer for making the sanitary napkins, and it functions as the closing layer. In order to prevent liquids from getting away, it performs the role of a barrier. In the present study two back sheet materials have been used i.e. Polyethylene (PE) for maxi and ultra-thin products; and PLA (polylactic acid) and PBAT (polybutylene adipate-co-terephthalate) for skiny-thin products. The basic specifications of these back sheets have been given in Table 3.4.

(a) **Polyethylene:** It is made using a polyethylene (plastic) film that lets air pass through but retain the liquid. It protects the absorbed fluid from getting contaminated or leaking. Bacteria can break down most of the sanitary pad's components expect polyethylene or polymeric films which will remain intact. This means once used napkin is disposed in public or private waste disposal system; it doesn't pollute the environment provided the synthetic back sheet protects the used wet napkin without exposing to the environment. The polyethylene back sheet has been procured from Dotpropack Industries Pvt Ltd, Maharashtra, India (Fig. 3.19).

(b) **Biodegradable Corn Poly-lactic-acid:** The role of a barrier sheet is to prevent the leaks and discolouration of the fluids. It contains a polyethylene film, which is breathable and has better fluid absorbency. Some components of sanitary napkins might increase the growth of bacteria that could harm both private and public disposal systems. However, the barrier sheet comprises polyethylene or polymeric films that decrease bacterial growth and protect the environment. Sustainability-based raw materials are should use as an alternative solution for hygienic products. Most hygienic items consist of these two non-biodegradable plastics as a protective film.

The choice of biodegradable plastics is the combination of polymer blends such as poly (butylene adipate-co-terephthalate) (PBAT) and polylactide (PLA). These capture attention as hygiene barrier films. The molecular weight of PLA has been 5-6 times better than the normal plastic items. PLA is a biopolymer that is a biodegradable plastic that is made from renewable resources (starch). The poly (butylene adipate-co-terephthalate) (PBAT) and polylactide (PLA) has been procured from Magical Film Enterprise Co., Ltd. Taiwan, Taiwan (Fig. 3.20).

Table 3.4 Specifications of polymer and manufacture method used for back sheets

Sr. No.	Type of back sheet	Polymer type	Manufacture method	Back sheet Code
1	Polyethylene film	Polyethylene	Polymerisation (film cast extrusion)	BS_1
2	PBAT and PLA film	Poly butylene adipate-co-terephthalate) (PBAT) and poly lactic acid (PLA)	Polymerisation (film cast extrusion)	BS_2

3.2.5 Adhesive Materials:

To ensure proper stability and functionality of a sanitary napkin, it is crucial that the different layers remain intact in the designated sequence as par design without bunching up or sliding from each other. In order to make sure that sanitary napkins work well and last as long as possible, certain adhesive materials also referred as glue are also used during the napkin manufacture. Various hot melt adhesives are available to meet the production challenges for feminine hygiene products. Recently some eco-friendly bio based hot melt adhesives are also introduced in the market. They withstand the absorbency demands and support positioning needs for the products.

Fig. 3.19 Polyethylene sheet

Fig. 3.20 PBAT and PLA sheet

These specialised materials for positioning sanitary napkins are specifically engineered for feminine care items to enhance both comfort and security for the user. The adhesive materials used for the making the napkin samples have been listed in Table 3.5. Construction adhesive and positioning adhesive had been obtained from Henkel Adhesives Technologies India Pvt. Ltd; Navi Mumbai (Fig. 3.21, Fig. 3.22). Bio-based hot melt adhesive was obtained from H.B. Fuller India Adhesives Private Limited, Pune, India (Fig 3.23).

(a) Construction Adhesives:

These adhesives are mainly use to maintain the specified position of various layers within a sanitary napkin's construction without bunching within the layers. They should provide a good adhesion ratio and reduce production flaws caused by material movement. These adhesives are used for construction of top sheet and backsheet, top and bottom tissue, acquisition distribution layer and air laid - SAP paper.

Fig. 3.21 Construction adhesive

Fig. 3.22 Positioning adhesive

Fig. 3.23 Bio-based hot melt polymer

Table 3.5 Specifications of various types of adhesive materials used in napkin samples

Sr. No	Type of adhesive	Code	Grade	Colour (Hue)	Viscosity (cps at150°)	Glue pot temperature (ºC)	Softening point (ºC)
1	Construction adhesive	AM_1	DM 2815	Transparent water white pillows	1500	150-170	75±5
2	Positioning adhesive	AM_2	DM 5358	Transparent water white pillows	4167	150-170	90±5
3	Bio-based hot melt adhesive	AM_3	Full-Care™ 5925	Transparent water white pillows	2000	150-170	75±5

(b) **Positioning Adhesive:** Positioning adhesive is specifically designed to secure sanitary pads in their intended location while it is required to use. The adhesive is applied on to the side wings and back sheet during the manufacture of sanitary napkins. It should provide high tack and good breathability for secured fit for applications on both wing and release paper.

(c) **Bio-based Hot-melt Adhesive:** The hygiene market has seen a clear manifestation of the sustainability trend, particularly in the increased focus on utilising natural materials derived from bio-renewable or waste feedstock. This approach has the potential to reduce carbon footprints. The hot melt adhesive conventionally utilise components derived from fossil fuels. However, in response to the need for more environmentally friendly alternatives, extensive research is currently underway to substitute some of these raw materials with bio-based, renewable materials. These technologies are designed to be highly efficient for important adhesive applications and contribute to reducing carbon emissions by substituting some fossil-based raw materials with bio-based, renewable materials.

3.2.6 Release Paper:

The release paper has various specifications, with a basic mass density range from 29 to 150 gsm. In the hygiene sector, medical care industry, and food industry, there are severe hygienic regulations. The same application encompasses silicone release paper for various feminine hygiene products such as women's pads, feminine sanitary napkins, panty liners, absorbent under-pads, nursing pads, and others.

Table 3.6 Detail specifications of release paper used for napkin manufacture

Sr. No	External material	Code	Mass density (gsm)	Width (mm)	Peeling strength (N/15mm)
1	Release paper	RP_1	29	50	0.1

Release paper is specifically engineered to facilitate effortless removal, minimising the likelihood of spontaneous detachment. Release paper procured form Spoton Coatings Pvt. Ltd. Surat; India (Fig. 2.24).

Fig.2.24 Release paper

3.3 Constructional details of Napkin Samples

A sanitary napkin or menstrual pad, (also known as a sanitary pad, sanitary towel, sanitary napkin or feminine napkin) is an absorbent item worn by women in their underwear when during menstruating period. These pads are made from a range of materials, differing depending on brand and style such as with wing, no wing, with tab or tab-less (Fig. 3.25). The wings or tabs that wrap around the sides of underwear help secure the pad in place to add additional leak protection. Depending on the napkin length generally four sizes of napkins are in use i.e. Regular, Large, Extra-large and XXL; however each case recommended minimum width of core layer should be 55 mm (Fig. 3.26).

Depending on the absorbency capacity the sanitary napkins are also classified as Panti liner, Ultra-thin, Regular, Maxi/Super, 'Maxi', Overnight, Maternity etc. Maxi or poly-maxi type napkins are the thicker variety most suitable for teen agers and young women seeking softness and comfort. Whereas perforated and double-perforated poly-maxi types of sanitary napkins are mainly useful for active sport women who perform their sport activities and regular fitness routines. A new type of 'Skiny-thin' napkin comprising of biodegradable materials also have been introduced to make the product environmentally friendly.

For comparative evaluation of performance characteristics study of sanitary napkins three categories of napkins have been designed viz. Maxi, Ultra-thin and Skiny-thin. ; in case of Maxi 4 types, in case of Ultra-thin 3 types and 3 types of Skiny-thin. Depending on physical dimensions 2 different sizes of Sanitary Napkins have been made viz. Large (length: 240 mm, (NS_{Ln})), and Extra Large (length: 280 mm, (NS_{XLn})) using core layer width of 55mm. Thus total of 20 Sanitary Napkin samples have been made 10 for each size (Table 3.7).

The napkin samples have been prepared comprising of at least three layers of various nonwovens and other materials as described in Sec 3.2 i.e. 8 types of top sheets (TS_n), 3 types of distributing layer (DL_n), 3 types of absorbing core layers (ACn) and 2 types of back sheets (BS_n). Each sample of the Sanitary Napkin code and its layer wise constructional details has been given in Table 3.7. The detailed layer wise constructional details of these samples have been shown in Fig.3.27, Fig. 3.28, Fig. 3.29, Fig. 3.30, Fig. 3.31, Fig. 3.32, Fig. 3.33, Fig. 3.34, Fig. 3.35 and Fig. 3.36.

Table 3.7 Constructional details of various samples of Sanitary Napkin

Sr. No	Napkin Category	Sample Code		Layers wise materials used in sample
		Large size	Extra Large size	
1	Maxi	SN_{L1}	SN_{XL1}	$TS_1 + DL_3 + AC_1 + AM_1 + AM_2 + RP_1 + BS_1$
2	Maxi	SN_{L2}	SN_{XL2}	$TS_2 + DL_3 + AC_1 + AM_1 + AM_2 + RP_1 + BS_1$
3	Maxi	SN_{L3}	SN_{XL3}	$TS_3 + DL_3 + AC_1 + AM_1 + AM_2 + RP_1 + BS_1$
4	Maxi	SN_{L4}	SN_{XL4}	$TS_4 + DL_3 + AC_1 + AM_1 + AM_2 + RP_1 + BS_1$
5	Ultra-thin	SN_{L5}	SN_{XL5}	$TS_3 + DL_1 + AC_2 + AM_1 + AM_2 + RP_1 + BS_1$
6	Ultra-thin	SN_{L6}	SN_{XL6}	$TS_4 + DL_1 + AC_2 + AM_1 + AM_2 + RP_1 + BS_1$
7	Ultra-thin	SN_{L7}	SN_{XL7}	$TS_5 + DL_1 + AC_2 + AM_1 + AM_2 + RP_1 + BS_1$
8	Skiny-thin	SN_{L8}	SN_{XL8}	$TS_6 + DL_2 + AC_3 + AM_3 + RP_1 + BS_2$
9	Skiny-thin	SN_{L9}	SN_{XL9}	$TS_7 + DL_2 + AC_3 + AM_3 + RP_1 + BS_2$
10	Skiny-thin	SN_{L10}	SN_{XL10}	$TS_8 + DL_2 + AC_3 + AM_3 + RP_1 + BS_2$

Among the 4 types of ‘Maxi’ category, 2 PP nonwovens and 2 PE perforated top sheets are used along with the same PE back sheet. However core layers made of different conventional absorbents materials of ADL, air-laid and sap paper. The 3 types of ‘Ultra-thin’ napkin category sanitary napkins consists PE perforated, PE double-perforated, and PE/PP laminated spun-bond nonwoven top sheets and PE back sheet. The basic material used in these samples made up of air-laid and SAP sheet. All 3 napkins of the ‘Skiny-thin’ category comprised of different biodegradable top sheets, a sustainable core layer, and an environmentally friendly PBAT and PLA-based biodegradable back sheet. These napkins prepared using organic cotton spun-lace nonwoven, silk spun-lace nonwoven, and corn-PLA base top sheets. The core element comprises of tissue paper wrapped with corn starch and bamboo pulp pulp-based air-laid paper sheet.

Fig. 3.25 Types of sanitary napkins with wing and without wing Fig. 3.26 different sizes of Maxi type

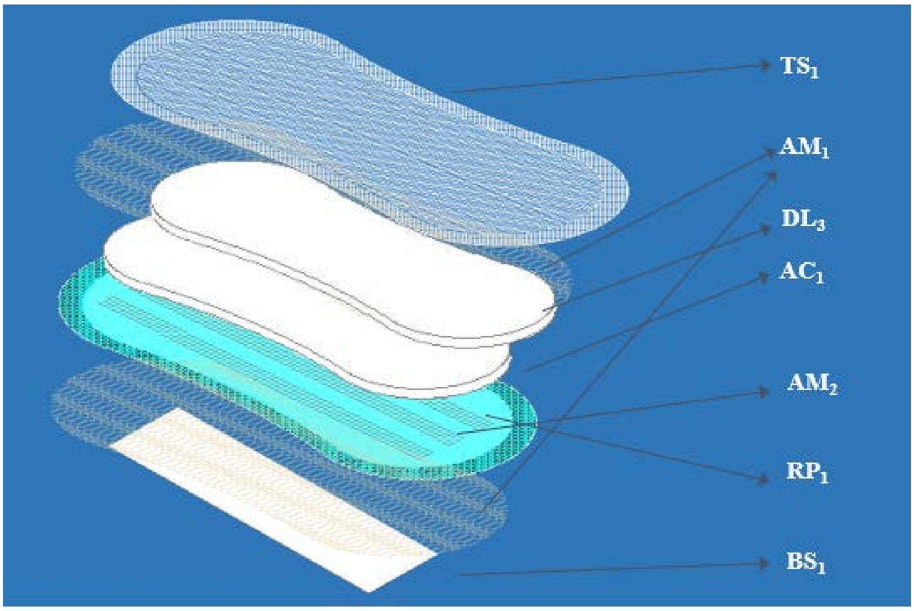


Fig. 3.27 Layer wise material used in Maxi Napkin sample SN_{L1} and sample SN_{XL1}

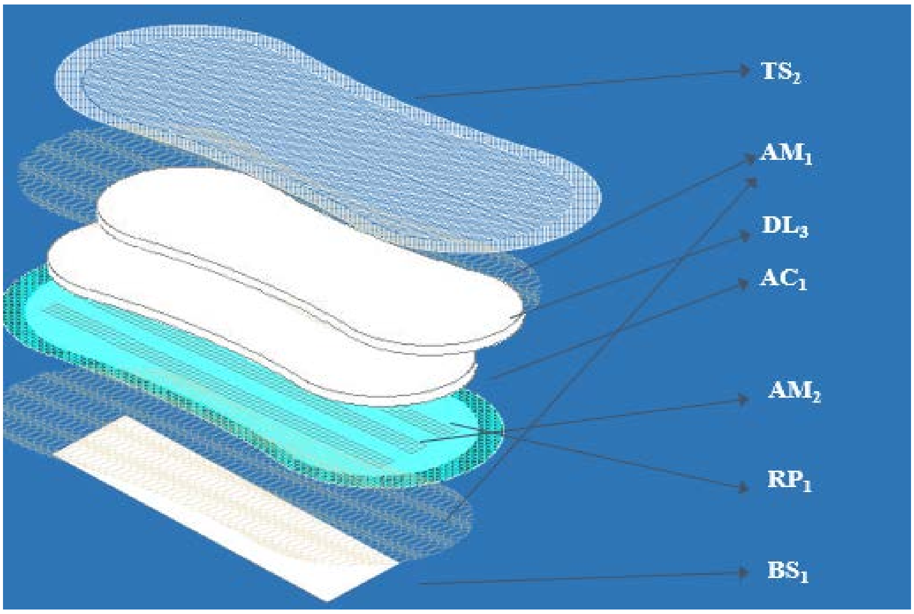


Fig. 3.28 Layer wise material used in Maxi Napkin sample SN_{L2} and sample SN_{XL2}

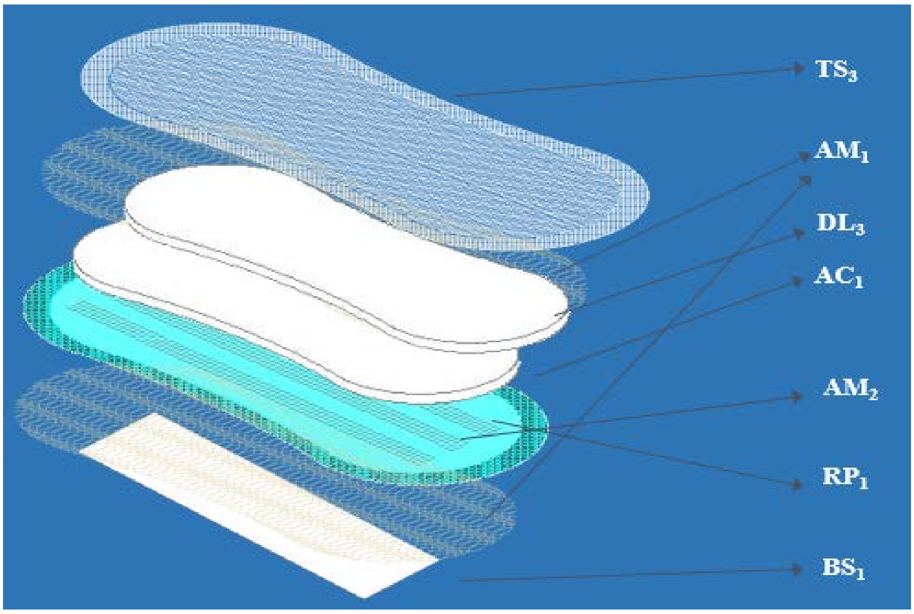


Fig. 3.29 Layer wise material used in Maxi Napkin Sample SN_{L3} and Sample SN_{XL3}

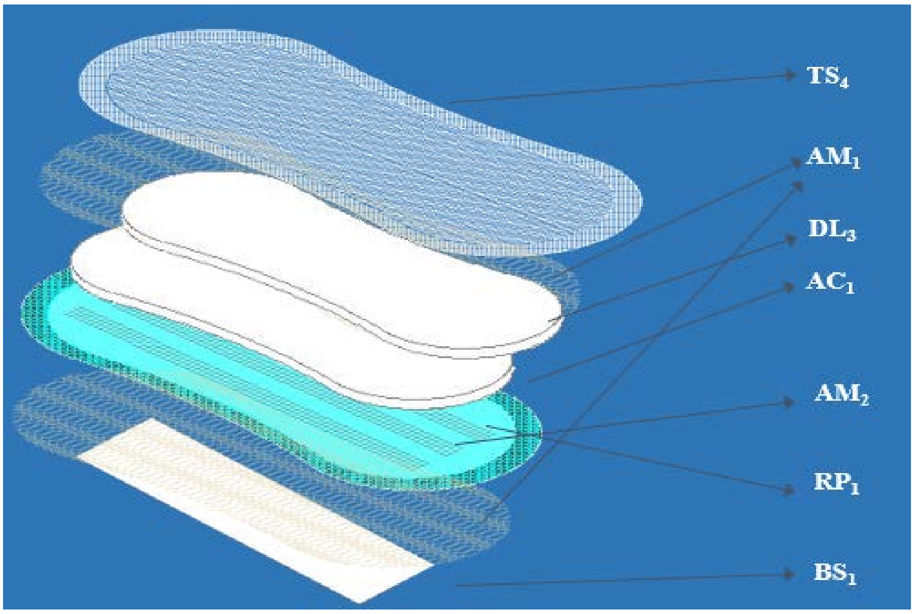


Fig. 3.30 Layer wise material used in Maxi Napkin sample SN_{L4} and sample SN_{XL4}

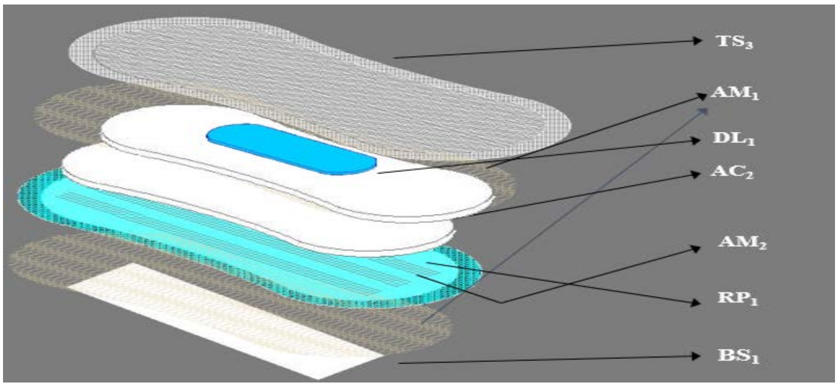


Fig. 3.31 Layer wise material used in Ultra-thin Napkin Sample SN_{L5} and Sample SN_{XL5}

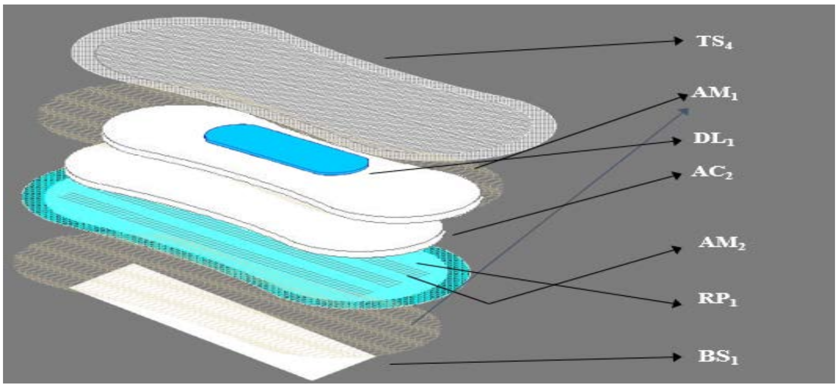


Fig. 3.32 Layer wise material used in Ultra-thin Napkin Sample SN_{L6} and Sample SN_{XL6}

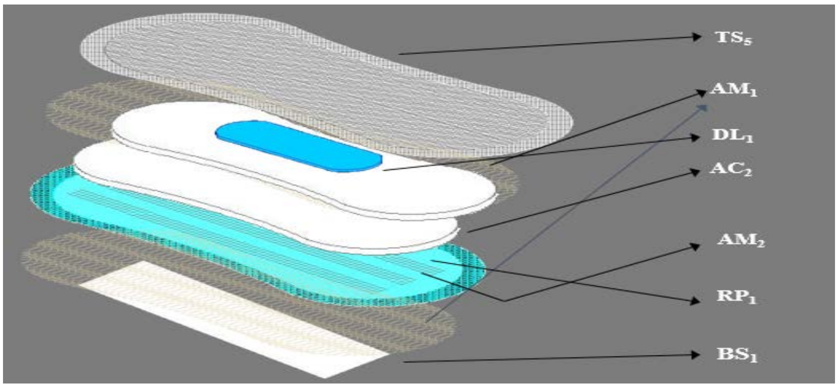


Fig. 3.33 Layer wise material used in Sample Ultra-thin Napkin SN_{L7} and Sample SN_{XL7}

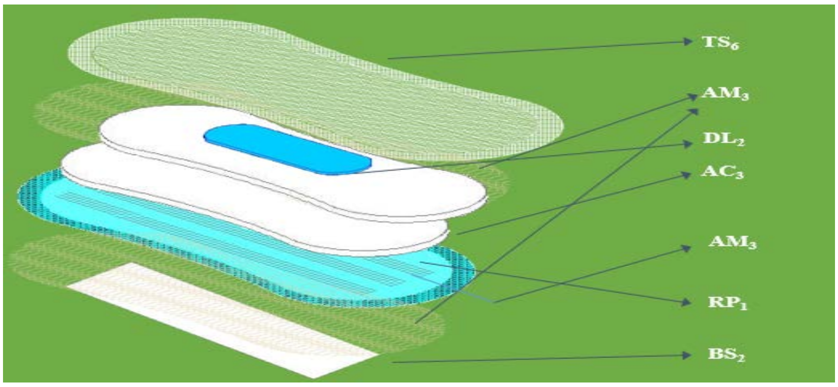


Fig. 3.34 Layer wise material used in Skiny-thin Sample SN_{L8} and Sample SN_{XL8}

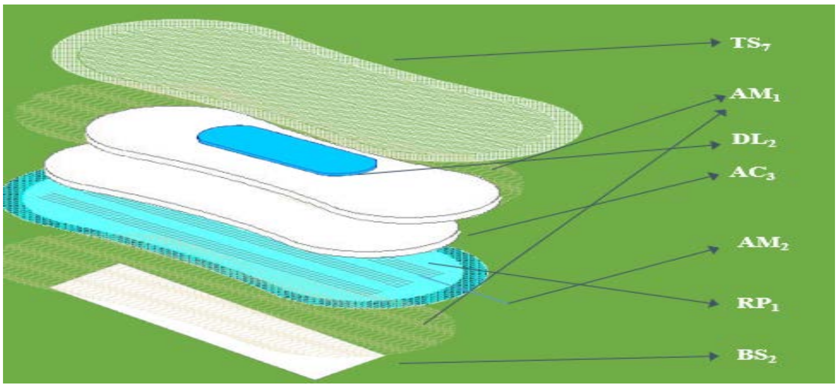


Fig. 3.35 Layer wise material used in Skiny-thin Napkin Sample SN_{L9} and Sample SN_{XL9}

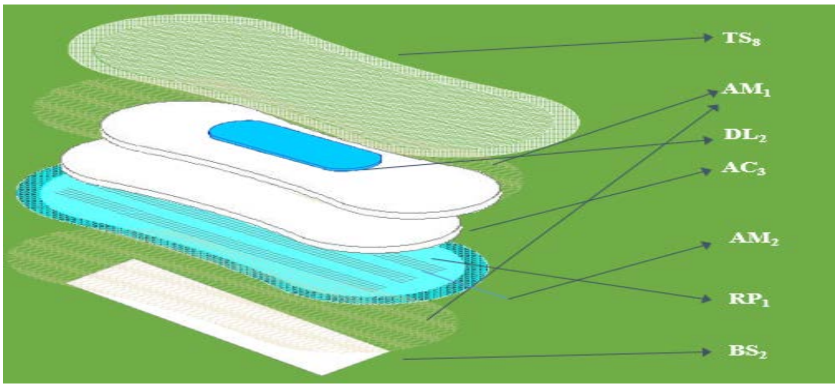


Fig. 3.36 Layer wise material used in Skiny-thin Napkin Sample SN_{L10} and Sample SN_{XL10}

3.4 Manufacture of Sanitary Napkin

Manufacturers of now use a combination of natural and manufactured materials to produce the sanitary pads. The technology of sanitary napkin manufacture and processing differs depending on the raw materials used, the shape, size and quantity of the finished products. The prime requirements of a sanitary napkin are cleanliness, absorbency, comfort, stability and adaptability to bodily movement. The selection of various raw materials has to be made depending of the design and specifications of the final product. For the present study it was decided to make samples of sanitary napkins of actual size using commercial machine in the industry set up. The production process is a step-by-step process of cutting, folding, and rolling the various components of the raw and auxiliary materials required for the product. The general process used for the sample napkins preparation is briefly described. The manufacturing details of process and machine have been described.

3.4.1 Process:

Napkin sample manufacture is carried out on machine using continuous process. The process lay out is in shown in Fig. 3.37. The sequence of main process steps is also briefly described.

- Raw material intake is pulp in rolls form obtained from pulp mill. It goes through a cylinder (Hammer) mill, where sheet is crushed, and converted in to fluff form. The feed of the pulp roll is regulated by a speed variater to control the fluff mass.
- A super absorbent powder (SAP) can be applied at this stage on the fluffed pulp.
- The fluffed pulp goes on top of a tissue paper forming the core layer which is folded in “C” form, in order to obtain the standard width of the napkins.
- A perforated (ADL) sheet is sealed with nonwoven and combined with top sheet.
- The continuous sheet of pulp and tissue is then cut in to pieces of required length (large or extra-large) by a rotary knife.
- A polyethylene film is inserted to protect the bottom of the napkins. The resulting pads are then spaced and passed on the non-woven cover which is then embossed and cut to give the shape of wings or round ends without wings by a die cutter.
- A permanent adhesive, protected by a silicon coated paper strip (MRP) is applied on back sheet, while self-adhesive wing release paper (WRP) is applied on the wings.
- Finished product with the folded wings is delivered to an automatic counter and stacker unit, which counts and discharges, the finished napkins.
- The operator inserts pre-counted napkins inside plastic bags and seal in to bag.

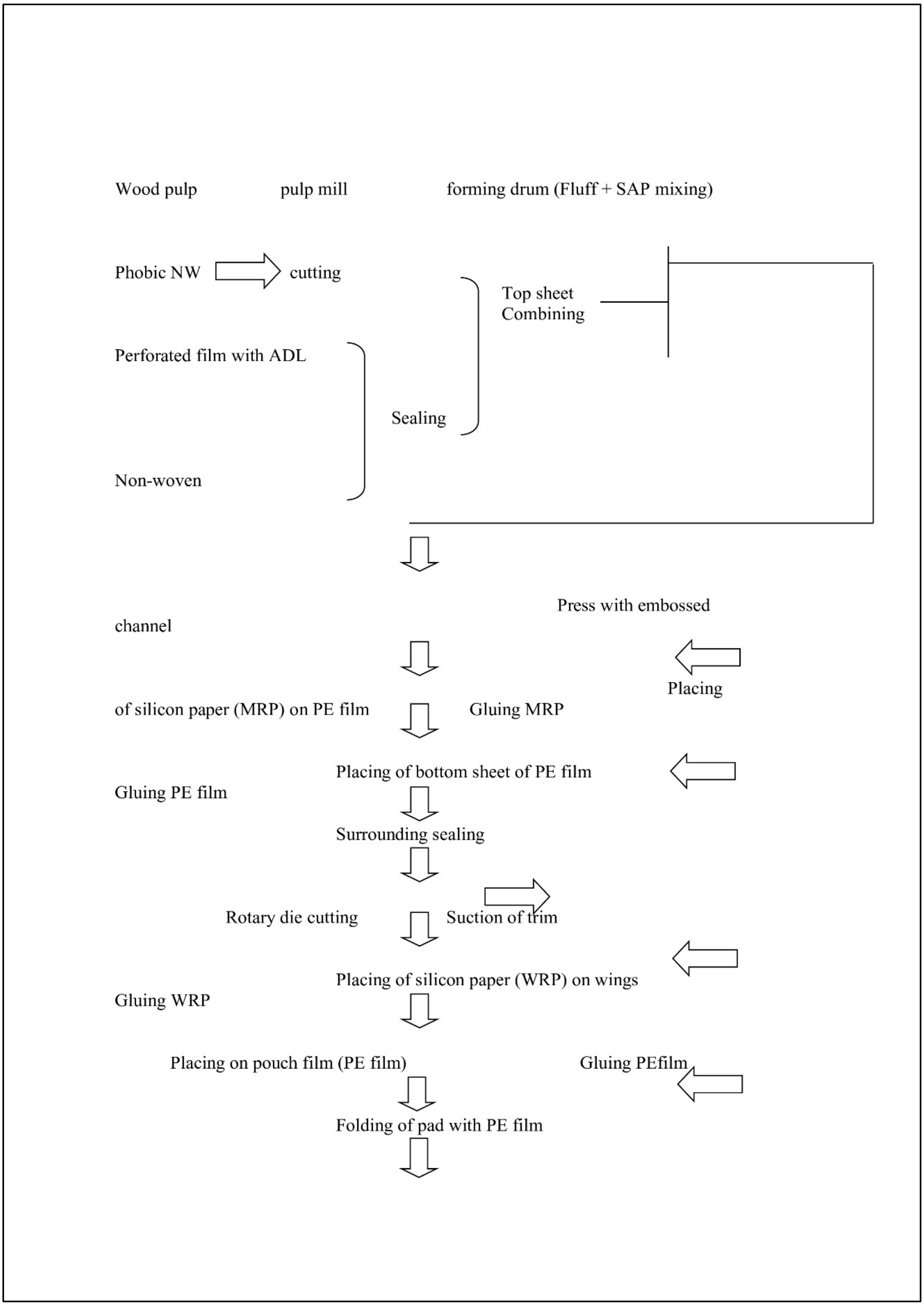


Fig. 3.37 Schematic diagram of manufacture of sanitary pad

3.4.2 Machine:

Preparation of napkin samples has been carried out at Shekani Industries Pvt. Ltd., Ahmedabad. The machine specifications, process flow chart, and details of main manufacture units have been given.

(a) **Machine Specifications:** The machine is comprising of various units for specific process such as core wrap unit, core cutting unit, core laminating unit, edge crimping unit, back paper release unit, final cutting unit, wing paper release unit. The tri folding and pouch cutting devices are also required for proper packing of the final products.

- Make: Heng Chang Machinery Co., Ltd (HCH), Anqing, China (Fig. 3.38).
- SIPL HCH M/C, Line 1 – Fempad machines
- Designed Speed: 800 PPM
- Production Speed: 700 PPM

Fig. 3.38 HCH Sanitary napkin manufacture machine

(b) Process flow chart: The flow chart of the sequence of the various process steps of manufacturing of sanitary napkins of this machine is shown in Fig. 3.39. Raw material for core is processed in Hammer mill. Core is cut depending on size of napkin in the Core cutting unit, followed by laminating with the top sheet and back sheet. Material them pass to edge crimping unit, back paper release paper unit, final cutter unit and wing release paper unit. Then the napkin is folded in to 3-fold for compact packing. Finally pouch cutting and sealing is done. Details these processes are as follows:

(i) Hammer Mill, Forming drum and Transfer drum

- The main raw material is untreated fluff pulp in rolls form. The pulp is pass through a cylinder (Hammer) mill (Fig. 3.40), where the pulp sheet crushed by crushing drum (Fig, 3.41), and converted in to the small fiber is fluff.
- The primary purpose of forming drum (Fig. 3.42) is to give the shape to the fluff material received from fibreiser (Fig. 3.43).
- The transfer drum passes the material from forming drum to the conveyor for further processing (Fig. 3.44).

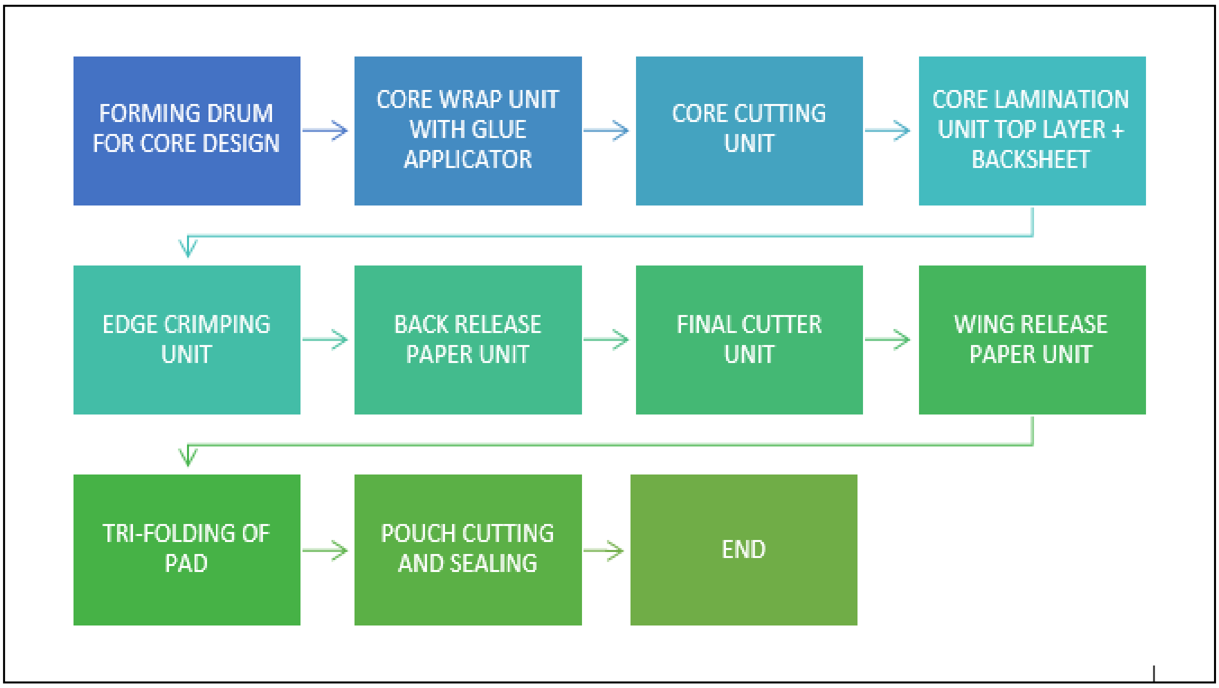


Fig. 3.39 Flow chart for manufacturing Sanitary Napkin

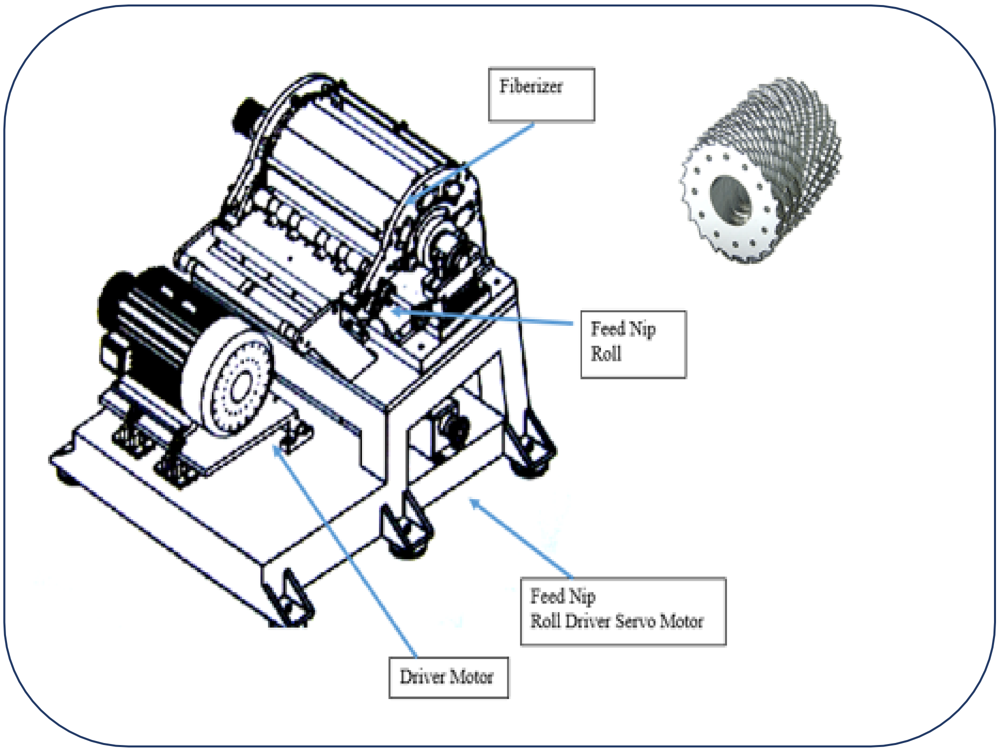


Fig. 3.40 Hammer mill (Cylinder roller)

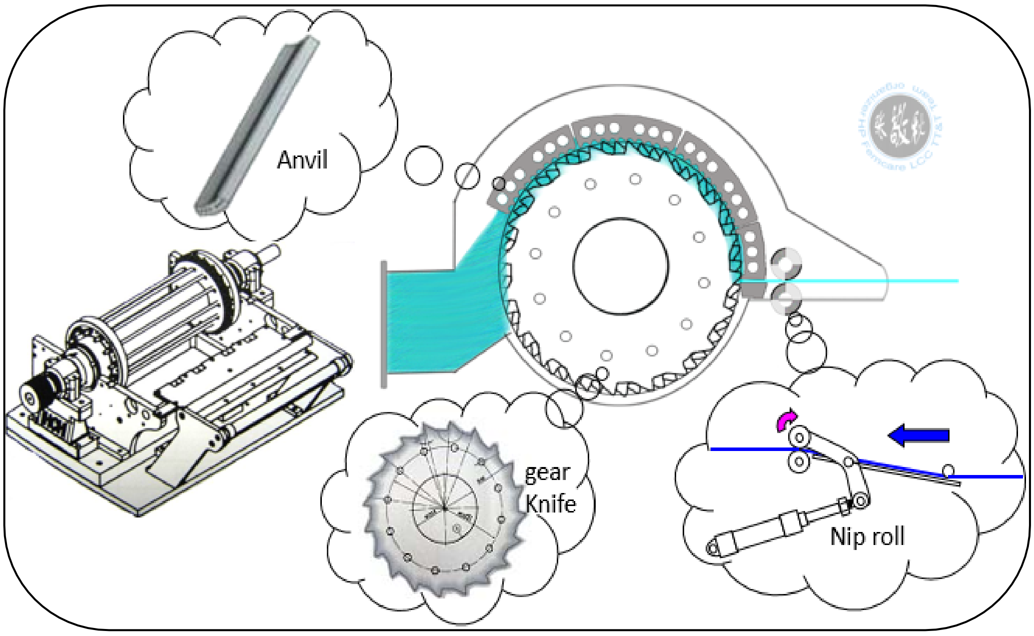


Fig. 3.41 Cursing drum, Transfer drum

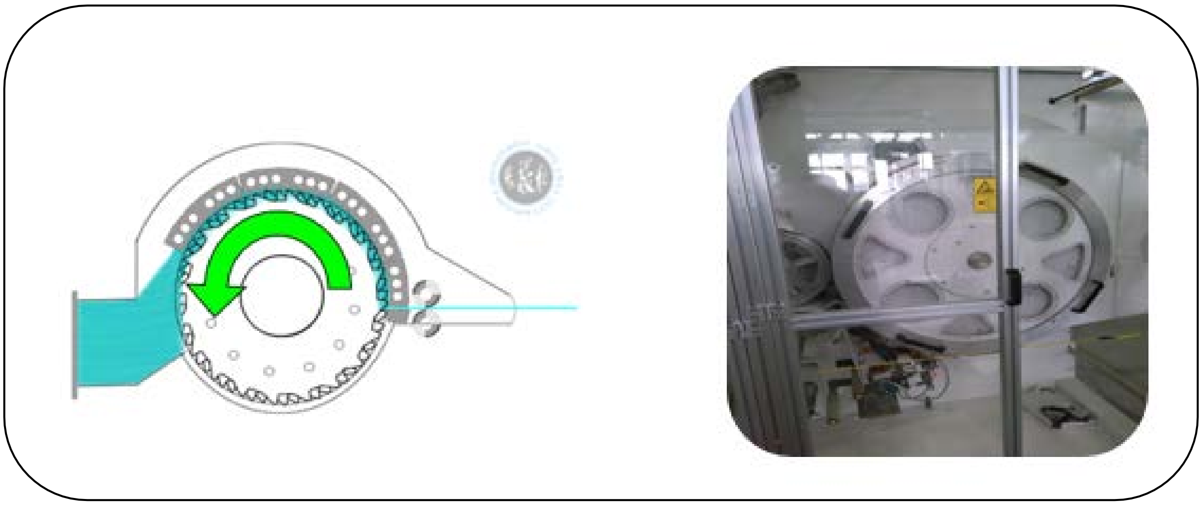


Fig.3.42 Forming drum -

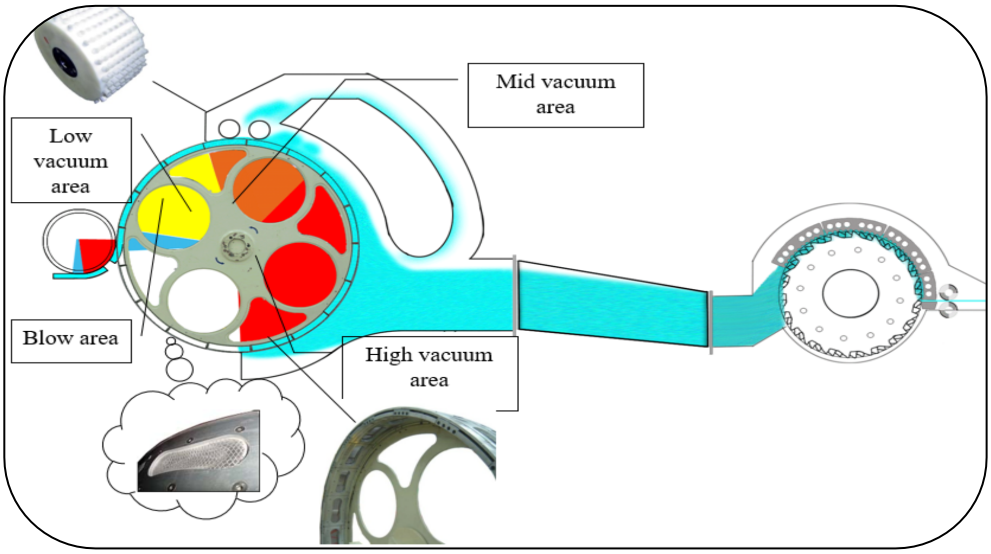


Fig. 3.43 Forming Drum for Core Design

Fig. 3.44 Core Mesh Drum (forming drum)

(ii) Conveyor and Web Assembly

- The material is fed on different conveyors through machine drive.
- The conveyors carry the formed material with different adhesives and raw materials to form the web (Fig. 3.45).
- The web is further supplied in other modules to carry out next processes.

Fig. 3.45 Conveyor and Web Assembly

(iii) Channel Module

- The web is then fed into channel module through conveyors (Fig. 3.46).
- The channel module gives channel impression on the material sheet and bonds the cover material to the main layer by using the adhesive.
- Module roll is maintained at required temperature to have effective channeling

Fig. 3.46 Channel module

(iv) **Seal Module Assembly**

- The web is then fed from channel module to seal module (Fig. 3.47)
- The seal module performs the sealing operation on the web.
- Adhesives are used to bond the cover and polymer web

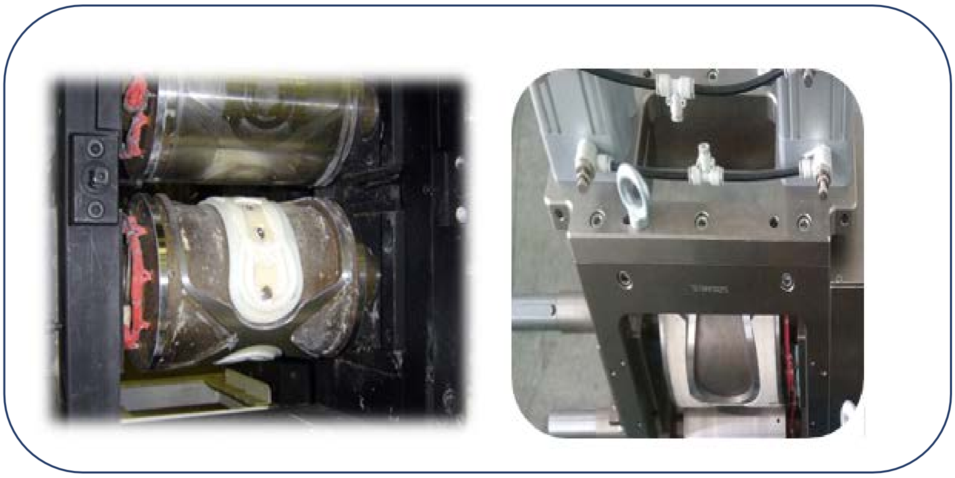


Fig. 3.47 Seal Module Assembly

(v) **MRP Cutting Unit**

- The web is applied with silicon coated MRP tape.
- The MRP tape is cut through a blade assembly and drum (Fig.3.48).
- MRP adhesive is applied on the MRP tape. This adhesive gets transferred on polymer sheet.

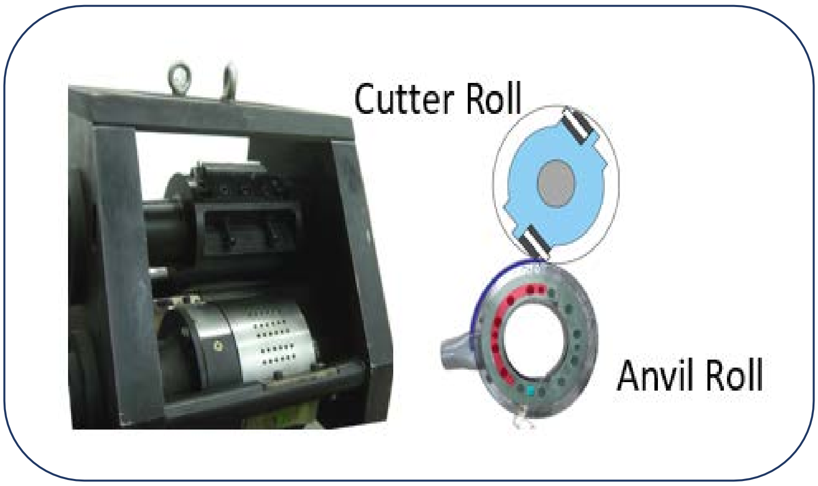


Fig. 3.48 MRP - Cutter Unit

(vi) Final Cutter

- The web then enters into final cutter.
- The final cutter gives final shape to the product (Fig. 3.49)

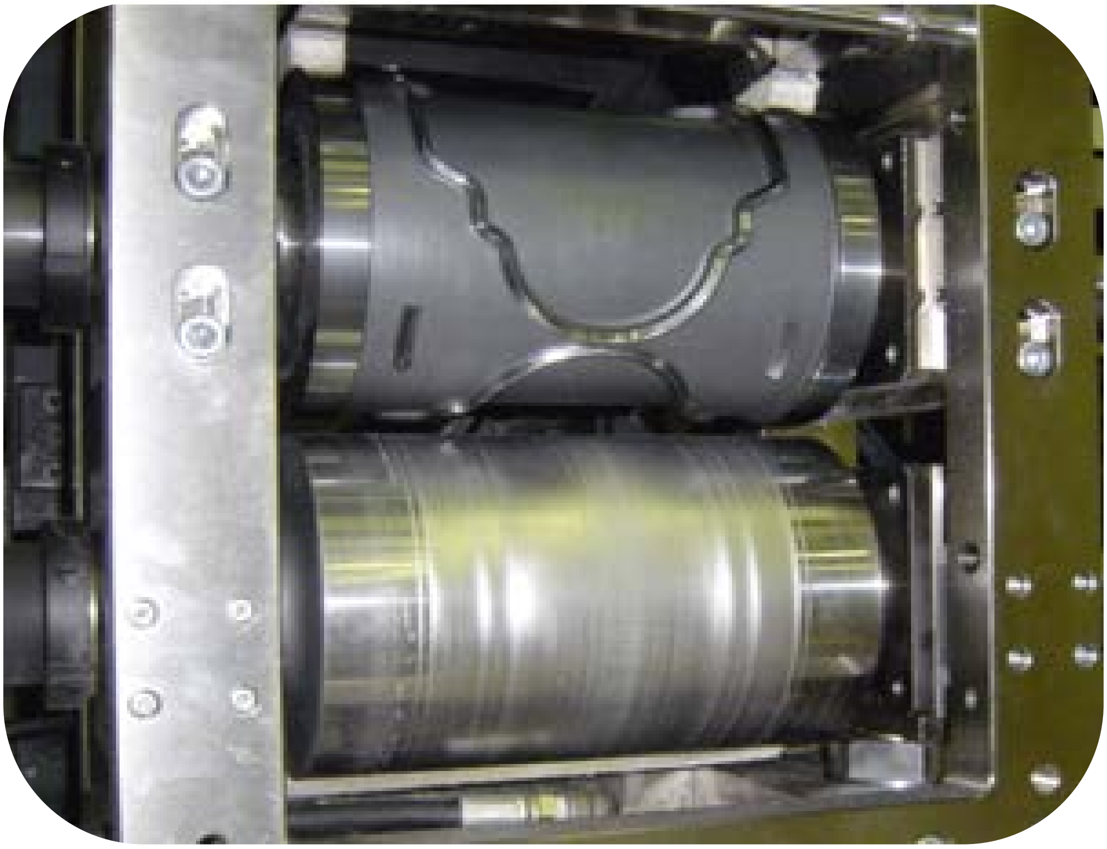


Fig. 3.49 MRP: Final Cutter Unit of Machine

3.5 Methods for Sanitary Napkin Testing

Sanitary napkin is one of the femcare products worn externally next to the skin under the under-wears. It has to mainly perform absorption process in which a fluid (adsorbate) is dissolved by or permeates a liquid or solid (the absorbent). Women utilize sanitary napkins during menstruation periods. These napkins should have the ability to absorb blood discharge without any leakage for a prolonged duration of time hence should be of excellent quality to prevent leakages and discomfort. The purpose of product tests is to evaluate essential characteristics such as the ability to absorb liquid to ensure comfort.

Evaluating performance can be accomplished by conducting laboratory experiments. Laboratory testing should be utilized to supplement the findings of user trials and analyze specific aspects of the product. Testing includes sampling, test design, scientific methodology, analysis, interpretation, and dissemination of findings. The guidelines are developed by considering the statistical approach and technological elements that affect test results. Under certain circumstances, the objective of the test may justify certain variations from this rule.

3.5.1 Physical and Mechanical Properties

The characteristics of raw materials used to construct the product affect the performance of the final napkin products. Hence the acquired raw materials have been evaluated for basic physical and mechanical properties such as fibre length, mass density, tensile strength, breaking elongation.

(a) Pulp fibre length: In case of nonwovens it is crucial to measure fibre length and diameter distribution for evaluating the fibre shape in biomedical research. Typically, the quantification of fibres in individual scanning electron microscopy (SEM) pictures is done manually. Data can also be acquired using laser scanning, the study of optical fibre diameter, the ensemble laser diffraction technique, micro-projection etc. An important aspect is statistically determining the minimum of 20 SEM images required to obtain accurate mean fibre length. The SEM images have been acquired using SEM machine at BITRA, Mumbai.

(b) Thickness: Thickness is important parameter for the napkin style and its contribution to aesthetic appeal for overall apparel look. Width of napkin is almost constant for most napkin types hence for a given length the thickness plays role in absorption capacity of the napkin. It is measure of distance between the face and back surfaces of the material under specific pressure. It's also helpful in estimating bulk of the napkin, which is thickness divided by mass per unit area (cm^3/g), and bulk density, which is mass per unit area divided by thickness (g/cm^3). Thickness tester used is shown in Fig. 3.50.

i) Apparatus:

- Thickness gauge
- Cutting dies

Fig. 3.50 Thickness tester for Sanitary napkin

ii) Conditioning

- Test the sample under the condition-Temp 23° ± 2°C and RH 50 ± 2%

iii) Sample Preparation

- Specimens should be cut 120 x 120 mm.

iv) Procedure

- Check to see that the thickness gauge has been calibrated correctly.
- Ensure that the specimen is positioned on the anvil.
- At least ten samples will be used once the machine has been tested and calibrated.
- Make sure to press the test button in order to start taking the test.
- Keep a record of the measurements taken from each sample.

(c) Fabric mass density: Non-woven fabrics are commonly used in disposable hygiene products to provide a more comprehensive solution. The mass density of these non-woven fabrics typically ranges from 10 gsm to 60 gsm having thickness in the range of 0.1 mm to 1.2 mm suitable for medical and hygiene items, including masks, diapers, sanitary pads, and adult incontinence products. Typically, fabrics with a higher mass density are thicker and more durable hence it is important to be considered in the selection for disposable hygiene products. It affects breathability, capacity to absorb moisture thereby comfort and reducing odours. These qualities make nonwoven materials ideal for the intended purpose. Sample has been cut into 20cm x 25 cm size (absorbent core was cut into the largest rectangular piece) and conditioned at 23°C and 50% relative humidity for 24 hours prior to measurement. Each sample was weighed using electronic weighing machine. Average mass per unit area have been calculated from 20 sample type. Mass density of these materials have been measured according to EDANA NWSP 130.1.R0 (15) standard**.**

(d) Tensile properties: Tensile strength is an important property of materials used in hygiene applications for better efficiency and quality in the production and stability, durability of products during its use. The maximum load the specimen can withstand before it fractures is its tensile strength. EDANA standard test procedure, NWSP 110.4 R0 (15) has been followed to determine the breaking force and elongation of samples. All samples were cut into 20 mm x150 mm strips and conditioned at 26°C and 50% relative humidity for 24 hours before the test. An Instron 5944 tensile testing machine (model 2580107) has been used (Fig. 3.51). Total 20 tests of each fabric sample have been carried out at traverse speed of 300 mm/min both in machine and cross-machine direction. Average tensile strength in N/50mm and elongation at break (extension %) have been noted. Tensile strength and Elongation at break are important properties. Simple tensile properties viz. tensile strength, elongation at break has been measured. It can also assess properties like tearing force, peeling force, shear force, adhesive force etc.

i) Procedure

- Cut the sample according to customer
- P&G method (100mm, 75mm)
- Wsp method (200mm)

- Web modulus (508mm)
- Used size for the study (200*50) (300*50)

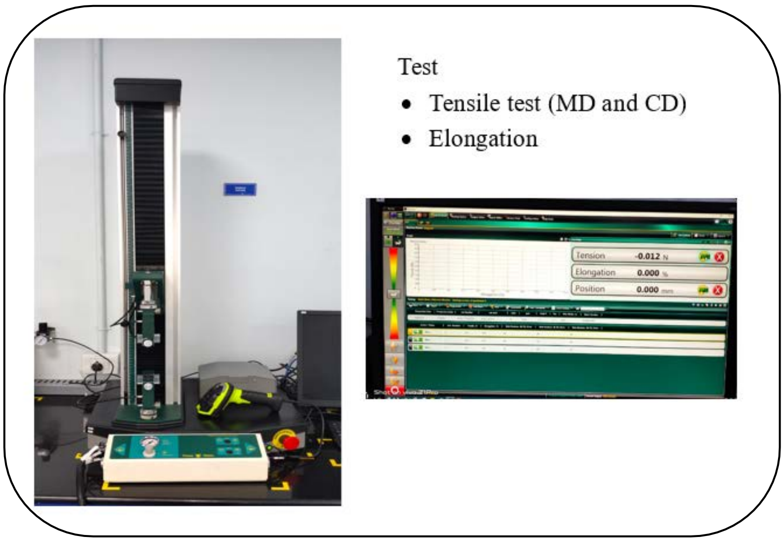


Fig. 3.51 Tensile testing machine

- Gauge Length (100mm, 75mm, 200mm)
- Put the sample in jaws
- Grip by Air pressure
- Start the test
- End the test
- Record the results

3.5.2 Performance Tests

When conducting performance-based comparative testing, it is recommended to test the primary product designs and/or the most commonly used size or product type is being tested. Performance attributes refer to characteristics that are typically observable or discernible by the consumer. While performance testing do influence user satisfaction, it is important to note that the relationship between performance test results and user satisfaction is not linear. Typically, a prospective customer is unaware of these attributes, unless the attribute hinders the regular functionality of the product. Various performance tests are required to assess the quality and effectiveness of both internal and external femcare products. Following characteristics evaluation and measurements have been carried out as par the standard tests mentioned in bracket in each case.

- **Strike through / penetration (pads/liners):** Strike through or penetration time refers to the rate at which a liquid is absorbed by the product [(Time in second) NWSP 70.3.R0 (15)].
- **Wetback (pads/liners):** Wetback, also known as rewet, quantifies the quantity of liquid that is discharged by the product onto the skin following absorption, under the application of pressure [(Discharge liquid in gram): NWSP 80.10.R0 (15)]
- **Absorbency and Rewet (pads/liners):** Various techniques are employed to quantify the absorbency of sanitary pads and panty liners. Several techniques have been devised to evaluate the ability to retain (absorb without leaking) substances. These approaches vary from basic designs (such as dunking and fluid acquisition) to more complex ones that consider shape and features to prevent leaks [IS 5405 – (2019)].
- **Adhesion/stay in place (pads/liners):** The final performance test focuses on the adhesive technology utilized to secure the product in position during its usage. Another aspect of the assessment is the extraction of the product from the garment once it has been used (EDANA).
- **Peel adhesion:** Peel adhesion test is used to determine the peel strength of pad with cotton fabric. Peel adhesion measures the force required to remove a pressure sensitive adhesive from a cotton fabric or its own backing material as per D1876 standard test method (**ASTM D3330)**
- **Seal strength:** This test is used to determine the maximum strength (peak load) of the seam of the feminine care pads. Seal strength is the tensile strength of the seal at ambient temperature. It is the maximum force required to separate the two layers of a seal under particular conditions (ASTM F88).
- **pH measurement:** Sanitary napkins should have neutral pH values; they should neither be acidic nor alkaline. For that, they are tested to determine their pH value.
- **Adhesive residue test:** Adhesive residue test is used measures the adhesive’s ability to adhere the fabric commonly used in the manufacture of underwear. As an adhesive tape is removed from a temporary application, the goal is to leave the surface as clean as possible.

(a) Strike through / penetration:

EDANA originated the test method which measures the strike-through time i.e. the time taken for a known volume of liquid (simulated urine) applied to the surface of a test portion of nonwoven cover stock, which is in contact with an underlying standard absorbent pad, to pass through the nonwoven. This is carried out using Lenzing instrument (Fig 3.52).

i) Apparatus

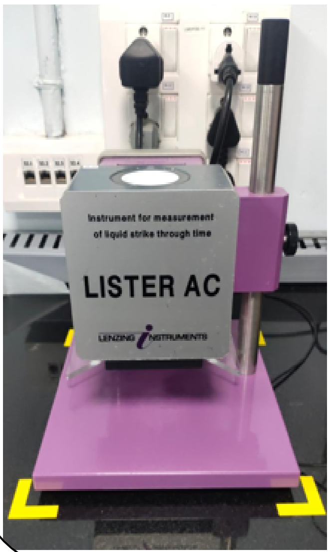
- Nonwoven Sample
- Burette (50 ml cap)
- Funnel (25 ml)
- Strike – Through Instruments
- Standard Absorbent Pad (Blotter Paper) (100 mm x 100 mm) Core filter paper (Ahlstrom Grade 989)
- Simulated Urine (Consisting of a 9 g/l solution of sodium chloride in distilled water)

ii) Conditioning

- Test the sample under the condition-Temp 23 ± 2°C and RH 50 ± 2%

iii) Sample Preparation

- Cut the specimen 125mm x 125mm



Specifications-
Manufacturing by- (LENZING instrument GmbH & Co.KG)
Type- Lister AC
Serial No. – L6184
Mod. – 2017
VAC – 230
Hz – 50-60
VA – 24

Fig. 3.52 Liquid strike through equipment

iv) Procedure

- Place one nonwoven test specimen on top of one set of 5 reference blotter papers on the base plate.
- Adjust the height (5 ± 0.5) mm above the top of the cavity in the plate.
- Ensure the electrodes are connected to the timer.
- Fill the burette with simulated urine; Keep the discharge valve of the funnel closed and run 5.0 ml of liquid from the burette into the funnel.
- Open the magnetic discharge valve.
- Record the time.

(b) Wetback

The test has been carried to examine the ability of napkin cover-stock to resist the transport back onto the skin the liquid which has already penetrated the cover-stock. The equipment used is shown Fig. 3.53.

i) Apparatus

- Nonwoven sample
- Simulated urine (Consisting of a 9 g/l solution of sodium chloride in distilled water with a surface tension of (70 ± 2) mN/m)
- Absorbent pad (paper 100 mm x 100 mm)
- Pick up Bottler Paper 125mm x125mm square
- Burette (50 ml capacity)
- Stopwatch
- Simulated body weight (total mass 4000 ± 20 g)
- A polyurethane foam rubber, 10 cm x 10 cm x 2 cm height

- **Specifications**
- Manufacturing by – LENZING Instrument
- Type – Wetback
- Serial No- 179
- Mod. – 2017
- VAC - 230
- Hz – 50-60
- VA – 12

Fig. 3.53 Wetback equipment

ii) Conditioning

- Test the sample under the condition-Temp 23° ± 2°C and RH 50 ± 2%

iii) Sample Preparation

- Specimens should be cut 125 x 125 mm.

iv) Procedure

- Cut the nonwoven test pieces in 125 mm x 125 mm.
- Prepare and weigh 1 set of 05 plies of filter paper.
- Calculate the loading factor of 05 filter papers by multiplying weight into loading factor.
- Place the nonwoven test piece on top of the set of 05 plies of filter paper.
- Place the strike-through plate on top of the nonwoven piece.
- Check whether the timer display shows zero.
- Dispense with the pipette or burette total liquid (weight of 05 plies of filter paper X loading factor) into the funnel, not all the liquid at a time.
- Remove the base plate with the sample and filter (blotter) paper and place it over Wetback instrument.
- Press the WET button; it will be placed on sample for 3 minutes.
- Remove the weight
- Weigh one layer of pick-up paper (W_1 g) and place it over the sample.

- Press the REWET button it will be placed for 2 min ± 2 s.
- Remove residual liquid by wiping the contact surface of the weight.
- Remove the weight.
- Weigh the wet pickup paper(W_2 g)

v) Calculation:

Wetback value (WB)g = W_2 g - W_1 g

(c) Absorption time and rewet:

Absorbency and rewet test of sanitary napkins have been carried using the instrument as shown in Fig. 3.54. Materials and Apparatus used: Synthetic blood, stop watch and dispenser.

i) Absorbency Test Procedure:

- Check the expiration date of synthetic blood.
- Swirl the synthetic blood solution gently. Ensure no bubbles are formed.
- Calibrate the dispenser for 15ml amount = 15.35 +/- 0.05 g
- Place the pad on the stand with the body side up.
- Centre the surface of the funnel on the pad.
- Entire oblong surface of funnel must touch the specimen.
- Position the dispenser center to the funnel.
- Simultaneously start the timing device and begin dispensing the entire amount of synthetic blood into the funnel.
- Depress the liquid with constant flow
- Do not move the funnel during all these activities
- Stop the stopwatch when the liquid in the funnel reaches the end point and record the time
- Remove the funnel from pad
- Rinse the dispenser and the funnel with distilled water and pat dry with paper toweling after approximately one set of testing to prevent synthetic blood build up

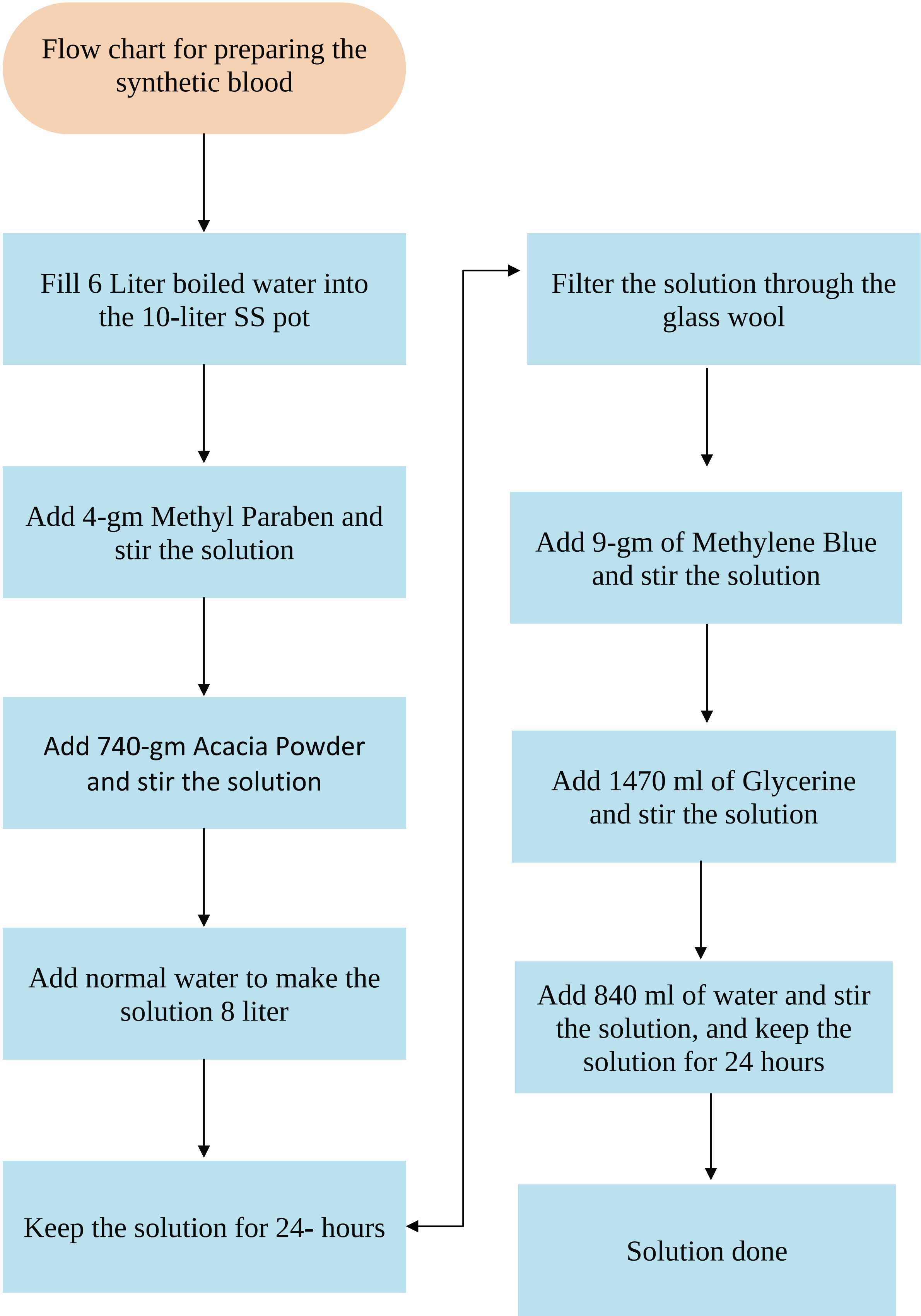


Fig 3.54 Flow diagram for preparation of synthetic blood

ii) Rewet Test Procedure:

- Use the same pad on which absorption test happened.
- Start the weighing scale and wait till Zero appears on screen.
- Weigh three pieces of tissue in bi-fold condition (W_1).
- Place the tissue properly in the center of the pad.
- Put the 5 kg metal block on center of the tissue.
- Simultaneously start the stop watch.
- After 5 minutes, remove the metal block accurately.
- Weigh the tissue and record (W_2).
- Calculate the difference W_2-W_1.
- Note down the rewet value in grams.

Fig. 3.55 Absorption and rewet instrument for sanitary napkins

(d) Adhesive residue:

i) Equipment used: Oven

ii) Procedure

- Wash hand to remove any oil/lotion. Do not touch the adhesive area at any stage.
- Cut off one end of the product just beyond the ends of adhesive lines. This will be test end. Cut up both sides and remove all components up to poly. Leave the adhesive and peel tape intact plus any entire piles of body wadding which are adhered to the adhesive at any point. The test sample must lay flat.
- Remove the peel tape. Place the fabric strip with minimum pressure on the pad with the fabric test side down with the long dimension covering the length of the adhesive lines. Lay the cotton down starting at the beginning of the adhesive lines on one end and extending beyond the adhesive lines on the opposite end. Use the 2 X 8 inch cotton strip.
- Lay the specimen on the metal plate in oven, fabric side up.
- Maintain oven temperature at 40.6 +/- 1^0C.
- Place the block on specimen. Line up the end of the weight with the end of the fabric and adhesive.
- Place 1600g brass block-weight with the 120 mm away parallel to the adhesive line.
- Close the oven door. Condition the specimen for 6 hrs.
- After 6 hrs. +- 1 min, carefully remove the weights and leave them in the oven.
- Remove the specimen from the oven and lay them out singly to cool for at least 15 minutes. Do not touch the adhesive test area.
- Never stack the warm specimen. Test within 1 hours of remove from the oven.
- Holding the end of the cotton fabric with the left hand used the right hand to peel the product away from the cotton fabric in a uniform motion, talking approximately 3 seconds for complete separation.
- The removal time of approx. 3 s is critical.
- Record the residue level for each specimen.

(e) Peel adhesion:

Equipment Used: Oven, Tensile Test Machine (Fig 3.56).

Fig. 3.56 Universal testing machine

Procedure:

- Wash hand to remove any oil/lotion. Do not touch the adhesive area at any stage in this procedure.
- Cut along both the sides of the product & remove all components up to the poly. Leave the adhesive and peel tape intact plus any entire piles of body wadding which are adhered to the adhesive at any point. The finished product must lay flat.
- Trim off 1 end of the specimen so that a fine line of adhesive is removed with the trim. The trimmed end will be the test end.

  Note: Alternate the ends from specimen to specimen so that the full length of adhesive has an equal chance to be tested.
- Peel back 2.25” (57 mm) of the peel and fold it back on itself.

- Place the fabric on the test trip.

  Note: center the 2 x 5 inch fabric in the narrow dimension and align the end flush with the cut end of the adhesive trip.
- Gently lay a fabric strip onto the exposed adhesive line with the test side of the fabric surface touching the adhesive. Apply no pressure. Used a new piece of fabric for each specimen.
- Lay the specimen on the metal plate in the oven with the fabric side up.

  Note: Do not keep the oven door open any longer than is necessary to place the blocks on the specimen.
- Set 250g weight on each specimen with the 50 mm dimension parallel to the adhesive lines. Line up the end of the weight with the end of the cloth and adhesive strip.

  Note: The weight should be near the peel tape fold. Do all this very gently to avoid undue pressure points on the adhesive.
- Closed the oven door & immediately start a stopwatch. Condition the Specimens for 60 minutes not to exceed 61 minutes.

  Note: Maintain oven temp. 40.6 +/- 1^0C
- After aging in the oven carefully remove the weight and leave them in the oven. Remove the specimen from the oven and lay them out singly to cool for at least 45 minutes. Do not touch the adhesive test area.

  Note: Never stack the warm specimens within 2 hours of removal from the oven.
- Before testing specimen set the gauge length on tensile testing m/c to 51 mm and crosshead speed to 500mm/min.
- When inserting the specimen onto the jaw squarely center the test specimen in width, between the front & back. Place the end of the product, which is under the tail end of cotton in the moving jaw of the tensile test. The cottontail is place in the stationary jaw.
- Start the crosshead.
- Return the crosshead after the test is complete. Note the reading of tensile testing m/c.
- Remove the specimen.

(f) Seal strength

i) Equipment Used: Universal Tensile Tester (Fig. 3.56)

(ii) Procedure:

- Place the template (25 mm wide X 50 mm long) on front/back end of pad.
- Cut along the template.
- Remove absorbent insert without disturbing the seal. If any portion of absorbent insert remains in the seal do not remove. But note this information.
- Switch ON the tensile tester.
- Set the distance between jaws 38 +/-1 mm; press Zero button.
- Insert the specimen's outer cover side into the stationary jaw with seal positioned to back. Insert the body side cover into the moving jaw. The seal must be centered and parallel to jaw faces.
- Initiate the test; the specimen will separate completely, ending the test.
- Record maximum force (peak load) to the nearest 0.1 gm. Remove the Specimen when the test is complete.

(g) pH measurement:

i) Procedure of calibration:

- Take buffer solution of 4.0 pH and 7.0 pH
- Pour 4.0 pH solutions into separate flask.
- Put the pH meter electrode in the 4.0 pH solution and turn ON the pH meter. Make sure that the meter is in pH mode.
- Press the Calibration button on the meter.
- Measure the value of pH when value on meter is stable, it should be 4.01 at 25 °C. If any difference is identified on scale then adjust the scale of pH meter
- Put the pH meter into 7.0 pH solution at 25 °C of buffer solution and set the value. If any difference is identified on scale then adjust the scale of pH meter.

ii) Precaution:

- Ensure the electrode of pH meter is completely immersed into the solution at the level mark given on pH meter.

- Hold the pH meter in solution and take reading carefully.
- Prepare the solution carefully to prevent any external content mixing.
- Handle the pH meter carefully to avoid any damages.
- Do not insert finger into the solutions.
- Periodically check for damage electrode.

iii) Equipment and materials:

- Glass stoppered flask made of chemically resistant glass for preparation of the aqueous extract.
- A glass stirring rod to shake the test pieces into distilled or deionized water.
- pH meter having suitable electrode system (Fig. 3.57)
- Beakers beaker of 250ml capacity, made of glass which is chemically resistant.
- Weighing scale having accuracy of 0.02gm.
- Erlenmeyer conical flask of 250ml capacity with flat bottomed and glass stopper
- Distilled or deionized water having pH value in range of 6.5 to 7.0.
- Standard buffer solution of 4 and 7 pH.
- Mechanical Shaker to provide to and fro movement

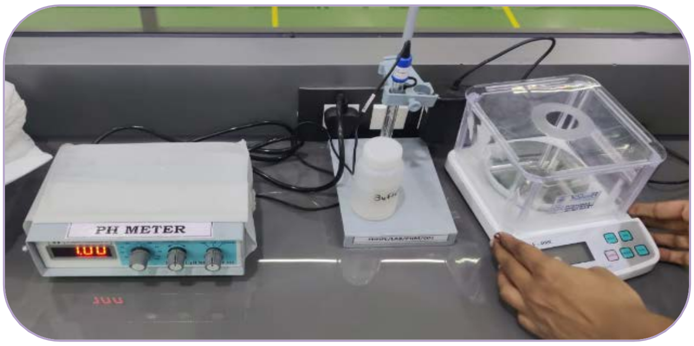


Fig 3.57 pH Meter

iv) Sample collection :

- Take the sample from product sample.
- Sample should not be preserved.
- pH should be tested immediately after sample collection.

v) pH testing method:

- Cut the test sample into pieces approximately 5mm in size or of size so that it can rapidly disposed in the solution.
- Weight the cut samples and take 2±0.05g
- Rinse the flask and take 100ml distilled water into stoppered glass flask.
- Mix the cut pieces (2±0.05gm) into the flask.
- Agitate the flask for 20-30 minutes by hand.
- Ensure that the specimen is properly wetted out.
- Shake it mechanically through mechanical shaker for 20-30 minute at fro movement rate of 60 per minute and rotational frequency of 30 per minute.
- Standardize the pH meter at the temperature of extract to be measured.
- Wash the electrode several times until the indicated pH value changes by not more than 0.05 in 5 minutes. If this cannot be realized, replace the glass and/or reference electrode.
- Decant the first extract into the beaker and immediately immerge the electrode to a depth of at least 1 cm and stir very gently with a glass rod until the pH attains its extreme steady value.
- Read the pH value.
- Decant the second extract into the beaker.
- Without washing transfer the electrode into the second beaker, lowering them gently to a depth of at least 1 cm, allow to stand without stirring until the pH attains its extreme steady value.
- Record this value to the nearest 0.1 unit of pH.
- Decant the third extract in another beaker and transfer the electrode to this beaker, again without washing
- Wait until the pH attains its extreme steady value.
- Record the pH value.
- The pH value of second and third extract is recorded as duplicate determination.