



Research Article

Reusable Sanitary Pad

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Abstract

Feminine hygiene products are described personal care products that are used by women to manage menstruation and to maintain menstrual health. One of the most preferred feminine hygiene products is sanitary pads. Sanitary pad is a thin pad made of absorbent material that comprises numerous layers of quilted cotton fabric or other super absorbent polymers and plastics. Soft touch, dry feel, odourless, leakproof and antibacterial properties are the expectations from a sanitary pad. Considering these expectations, in order to replace with the disposable (single use) ones we have developed a reusable sanitary pad with wings that all individual layers of fabrics are designed and produced. Drying time, pilling resistance, thermal and water vapour resistance, air permeability, dimensional stability, hydrostatic pressure, tensile strength, tear strength, phenolic yellowing, pH level, bursting strength, thickness, mass per unit area tests are carried out.

According to market outlook reports the total sales of reusable sanitary pads represent ~5%- 10% of the global health and personal care market. Disposable (single use) sanitary pads end up with landfilling and disposal by incineration and cause environmental pollution. From the perspective of woman health, equality of opportunity, sustainability and environmental health concerns it is concluded that reusable pads are a sustainable alternative for the disposable (single use) ones.

Keywords: Reusable Sanitary pad, Disposable (single use) Sanitary Pads, Absorbency, Dry Feel, Thermal Comfort, Leakproof.

1. Introduction

The textile industry is hold responsible for water pollution, greenhouse gas emissions and landfill [1]. On 30th of March 2022 EC has published EU Strategy for Sustainable and Circular Textiles document that underlines the production of reusable repairable, recycled, recyclable and long life textile products to minimize the incineration and landfill [2]. Therefore, the researchers are developing the reusable alternatives to disposable products. One of these product segments is feminine hygiene products. Disposable (single use) nonwoven hygiene materials are still popular in the market but the percentage of reusable ones are also increasing. It is estimated that reusable sanitary pad market will continue to grow with a CAGR of 11.6% in a decade reaching a valuation of US\$ 8.3 Billion [3].

A reusable sanitary pad consists of three different functional layers as seen on Figure 1.

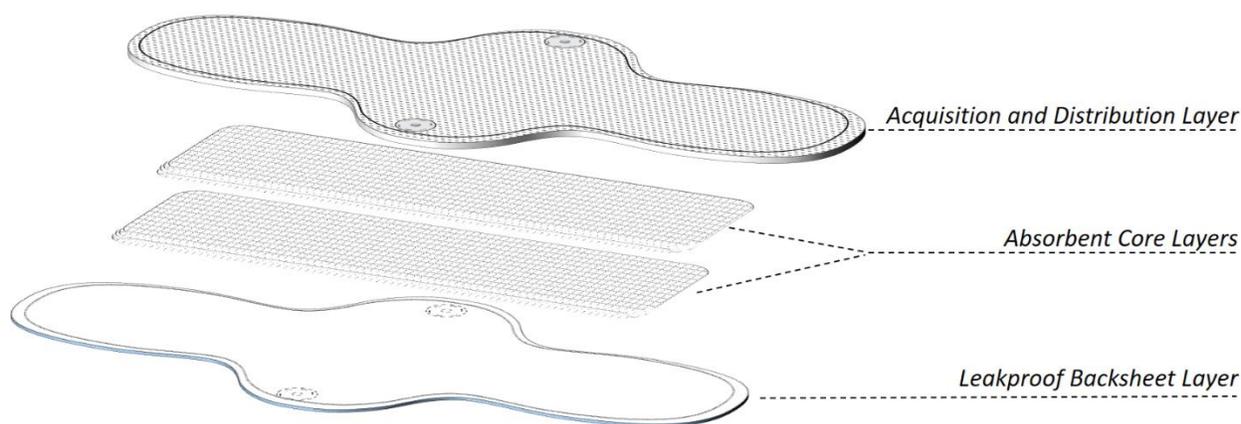


Figure 1 Functional layers of a reusable sanitary pad

On the top, there is a layer for acquisition and distribution (ADL) to transfer the menstrual fluid to the absorbent core layer. Absorbent core layer lays in the middle, which absorbs and retains the menstrual fluid. At the bottom there is a third layer (backsheet) which prevents the leakage of the fluid and staining on the underwear [4,5].

In this study we have designed a reusable alternative to the disposable (single use) sanitary pads. In this perspective, physical, chemical, thermal comfort, permeability properties of the designed layers are tested and the results are evaluated.



2. Materials and Methods

Knitted fabrics produced from polypropylene, polyester and woven fabrics from cotton fibers are used in this study. Polypropylene has low density, low thermal conductivity, zero water absorption, quick dry properties. Also it is resistant to different chemicals which results from inherent inertness of the fiber. Therefore, it is not skin irritant and lastly resistant to pilling. The fabric has a soft and dry touch to the skin, which is important for the physiological comfort of the wearer. The fabric also distributes and transfers the liquid to the absorbent core. Designed birdseye structure is commonly preferred in moisture management applications (activewear, sportswear). 215 g/m², 28 Fein 75D/72F 100% PP structured interlock (birdseye) knitted fabric is designed as a top sheet acquisition and distribution layer in order to take advantage of the properties of polypropylene fiber and the knit structure.

Muslin fabrics are absorbent and lightweight. They have a loose and multilayer weave construction that enables the fabric to dry faster and contributes to the absorption capacity. Two layer and four layer, 120 g/m² and 230 g/m² respectively, 30/1 Ne 100% CO multilayer muslin woven fabrics are used in the absorbent core.

For the leakproof back sheet layer, 60 g/m² 36 Fein 50D/72F 100% PES single jersey knitted fabric and 15 micron PES membrane are laminated using hot melt lamination technique with polyurethane based adhesive. In lamination process, adhesive is applied in the form of a dot coating that allows water vapour to penetrate through the fabric.

Applied test names and methods are given in Table 1.

Table 1 Tests and methods

<u>Test Name</u>	<u>Method</u>
Determination of mass per unit length and mass per unit area	TS 251:1991
Thickness	ASTM D1777-96:2019
Determination of dimensional change in washing and drying	EN ISO 3759:2011, ISO 6330:2022, TS EN ISO 5077:2009
Determination of pH of aqueous extract	ISO 3071:2020
Determination of fabric propensity to surface pilling, fuzzing or matting	ISO 12945-2:2020



Table 1 Tests and methods (continued)

Test Name	Method
Assessment of the potential to phenolic yellowing of materials	ISO 105-X18:2007
Determination of the permeability of fabrics to air	ISO 9237:1995
Determination of maximum force and elongation at maximum force using the strip method	ISO 13934-1:2013
Determination of tear force of trouser-shaped test specimens (Single tear method)	ISO 13937-2:2000
Pneumatic method for determination of bursting strength and bursting distension	ISO 13938-2:2019
Determination of resistance to water penetration – hydrostatic pressure test	ISO 811:2018
Measurement of thermal and water-vapour resistance under steady-state conditions (sweating guarded-hotplate test)	ISO 11092:2014
Drying time of textiles	based on AATCC 199:2018

Four different combinations of muslin fabrics are evaluated in the absorbent core structure. Layers of the sanitary pad are given in Table 2.

Table 2 Layers of the sanitary pad

Layer / Function	PP Knitted Fabric	2 Layer Muslin Fabric	4 Layer Muslin Fabric	4 x 2 Layer Muslin Fabric	2 x 4 Layers Muslin Fabric	Membrane Laminated PES Fabric	Final Pad Structure
ADL	X						X
Absorbent Core		X	X	X	X		X
Back Sheet						X	X



All samples are conditioned for 24 hours at 20 °C 65% RH atmosphere before testing. For the drying time determination tests, the fabrics are cut into 60 mm x 60 mm width - length and weighed. Readings are recorded as dry weight (W1). Then fabrics are immersed in distilled water for 1 minute and hung on vertical stand for 5 minutes. They are weighed and readings are recorded as saturated weight (W2). Moisture retention of the fabrics are determined using formula 1.

$$\text{Moisture Retention (\%)} = ((W2 - W1) / W1) * 100 \quad (1)$$

where:

W1 = dry weight, in g

W2 = saturated weight, in g

Formula 2 is used to determine the amount of water to add to the fabric.

$$y = x \cdot W1 \quad (2)$$

where:

y = the amount of water to add in mL

x = moisture retention (the result of formula 1)

w1 = dry weight, in g

Tests are carried out in SDL Atlas Sweating guarded hot plate M259B model device at R_{ct} measurement mode under 20 °C, 65% RH environment (air speed is 1 m/s, plate heat is approximately 35 °C). The 60 mm x 60 mm fabric samples are wetted with the pre-determined amount of distilled water, placed in the sweating guarded hot plate and weighed every 30 minutes until they reach to dry weight.

3. Results

Test results are summarized on the table 3.



Table 3 Test results of the layers

Layer / Test	PP Knitted Fabric	2 Layer Muslin Fabric	4 Layer Muslin Fabric	4 x 2 Layer Muslin Fabric	2 x 4 Layers Muslin Fabric	Membrane Laminated PES Fabric	Final Pad Structure
Mass per unit area (g/m ²)	215	120	230	432	450	82	744
Thickness (mm)	1	0,7	2,00	2,50	3,34	0,28	5,27
Dimensional stability (%)	Width +5,3	Width -6,1	Width -6,2	Width -4,1	Width -4,0	Width -5,0	Width -1,0
	Length +4,4	Length -4,0	Length -6,2	Length -3	Length -4,0	Length +5,0	Length -1,8
pH (grade)	6,76	6,68	6,87	6,68	6,85	7,2	-
Resistance to pilling (grade)	7000 cycle 4/5	1000 cycle 3/4	1000 cycle 3	1000 cycle 3/4	1000 cycle 3	>50000 cycle 4/5	-
Phenolic yellowing (grade)	3/4	4/5	4/5	4/5	4/5	4	-
Air permeability (mm/s)	265	2200	1550	960	820	0	-
Tensile strength (N)	-	Warp 302 Weft 246	Warp 454 Weft 424	-	-	-	-
Tear strength (N)	-	Warp 25,7 Weft 33,7	Warp 55,5 Weft 71,3	-	-	-	-
Bursting strength (kPa)	590	-	-	-	-	531	>617
Resistance to water penetration (mmH ₂ O)	-	-	-	-	-	>10000	>10000



Table 3 Test results of the layers (continued)

Layer / Test	PP Knitted Fabric	2 Layer Muslin Fabric	4 Layer Muslin Fabric	4 x 2 Layer Muslin Fabric	2 x 4 Layers Muslin Fabric	Membrane Laminated PES Fabric	Final Pad Structure
Water vapour resistance (m ² Pa/W)	3,25	3,15	7,72	11,7	15,3	1,37	31,93
Thermal resistance (m ² K/W)	0,0141	0,0244	0,0643	0,0823	0,1084	0,0007	0,1193

It can be seen that in table 3 tensile strength, tear strength and bursting strength of the layers are enough to meet the requirements of repeated washing cycles. Also the dimensional stability of the fabrics are within the $\pm 5\%$ range except four-layer muslin fabric. Apart from other layers, both top and backsheet layer will be subject to friction with the skin and the underwear respectively. Therefore 7000 and 50000 cycles are applied on these layers and both are grade 4/5.

Two-layer muslin fabric has a higher air permeability (2200 mm/s) than four-layer one (1550 mm/s). But when the air permeability of two-layer and four-layer muslin fabrics are examined, to obtain eight layers in total, a 56% decrease is seen in two-layer muslin fabric, while there is a 47% decrease in four-layer muslin fabric.

Hydrostatic pressure test result for the PES membrane laminated PES fabric is more than 10000 mmH₂O which is mostly dependent on the membrane properties. R_{ET} and R_{CT} values are 1,37 m²Pa/W and 0,0007 m²K/W respectively, which are very good results for the backsheet layer.

Drying time graphs are given in figure 2.

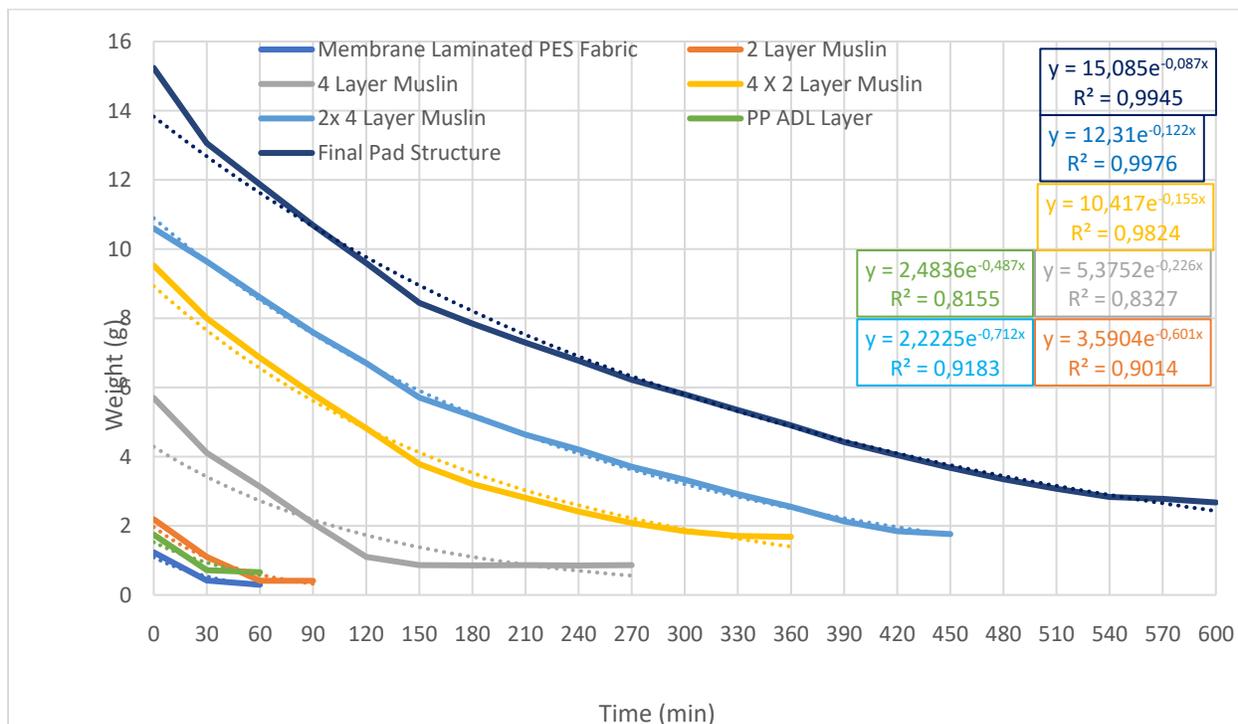


Figure 2 Drying time graphics of layers

It can be seen in Figure 2 that the fabrics produced from hydrophobic nature fibers dry faster than the hydrophilic ones, as expected. Although four layers of two-layer fabric dries slightly faster than the two layers of four-layer one, the ratio of the amount of water required to saturate the fabric to the dry weight is 4,34 and 5,71 for the two-layer and four-layer fabrics respectively. Also the coefficient of determination is higher for the four-layer ($R^2=0,9976$) compared to two-layer ($R^2=0,9824$) in drying time tests. In the final structure we used two layers of four-layer muslin fabric to ensure absorption capacity for heavy flow. Design can be modified and only one layer of four-layer muslin fabric can be used for light flow.

Since the backsheet prevents air permeability, the drying time of the pad is as long as 10 hours, but this time can be reduced by a reversible design, which allows absorbent core to be subjected to more air flow and more evaporation.

4. Discussion and Conclusion

Disposable (single use) pads still have the 90-95% share in the market. A average disposable sanitary pad comprises 48% fluff pulp, 36% PE, PP and PET, 7% adhesives, 6% superabsorbent and 3% release paper [6]. In Europe approximately 87% of of single-use menstrual products ends up in landfills. Some components can take up to 500 years



to break down. They release toxic chemicals and generate microplastics into the environment as they degrade. Besides environmental problems there are also social ones like equality of opportunity in reaching these products which is called period poverty [7]. The development of reusable alternatives to these products will contribute to minimizing such problems.

In this study we have designed and tested a pad fabric considering the availability of the fabrics in the fabric stores. It is concluded that the requirements of a sustainable sanitary pad can be met with the developed fabrics.

5. Acknowledge

This study was carried out as a domestic project in Sun Tekstil R&D Center and supported by our own resources.

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