

Development of Reusable Urine Leak-Proof Underwear with an Innovative Knitted Fabrication

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I. INTRODUCTION

Urinary incontinence is a considerable health issue that affects people's quality of life worldwide, many of them are female [1]. The development of reusable urine leakproof underwear is a significant innovation in solving the problems faced by people with urinary incontinence. Two main features that contribute to the effectiveness of these undergarments are absorbency and wicking properties. High absorbency, less bulk, and quick dry properties are desirable qualities in fabrics preferred for the inner layer of urine leakproof underwear [2].

Absorbency in textiles is critical to a fabric's capacity to take in urine and prevent leakage to outerwear. There are urine leakproof undergarments with multiple layers on the market, including disposable and reusable materials. Those garments can absorb substantial quantities of urine. However, it had less absorbency capacity and bulk products. According to the previous literature, consumer requirements for a urine leakproof undergarment were identified, and a solution for it [3].

The construction of this urine incontinence underwear often features a specialized layer that enhances absorbency, less bulk, quick drying, and a comfortable fit [4]. This design ensures leak-proof protection and comfortability by using seamless bonding technologies. Furthermore, the moisture-wicking ability of polyester-cotton spacer fabric actively absorbs the urine from the polyester side and quickly dries by entering urine into the cotton side.[3] Then, cotton yarns absorb urine rapidly and spread the gusset area evenly. With this innovative knitted fabric, polyurethane-coated polyester fabric was attached by bonding to the gusset area to ensure leakproof protection. Water retention v-fold bonding tape is used to achieve better leakproof protection of this gusset. Cotton-polyester spacer fabric is knitted to achieve performance such as high absorbency, less bulk, and quick dry properties [5]. When a drop of urine is released, it enters the fabric through the polyester side and absorbs that urine from the cotton side of the innovative fabric. This developed fabric enhances the lightweight quality of our urine leakproof undergarment by seamlessly integrating multiple layers for improved performance compared to existing products.

Hence, reusable urine incontinence ladies' underwear was developed with high absorbency and less bulk after developing the prototypes and testing their functionalities. Also, innovative fabrication has been engineered to significantly enhance the absorbency and comfort of undergarments while fulfilling the current trend in the textile industry.

II. METHODOLOGY

A. *Identify requirements for urine leakproof underwear and suitable textile materials and manufacturing techniques to meet those requirements.*

High absorbency, leak-proof protection, breathability, less bulk, comfortability, elasticity, and durability were identified as the main requirements for developing urine leakproof underwear. An innovative spacer fabric is developed to achieve high absorbency, less bulk, and quick dry properties of the fabric. The inner side of this spacer fabric includes Polyester 2/150/144 BR DTY yarns. The high filament count of polyester yarns enhances the wicking ability of the fabric and allows for effective moisture transfer, keeping the skin dry and comfortable. Also, this high polyester filament count positively affects the soft feel and breathability of the inner side. The other side of the spacer fabric includes Cotton 40Ne/4 FD yarns to enhance a better absorbency of urine. Polyester 1/75/72 SD FDY yarn is used as the binding yarn for this spacer fabric.

Polyurethane-coated polyester fabric is used as the moisture barrier layer with this innovative spacer fabric for enhancing leakproof protection. Tape bonding is used for the urine leakproof undergarment to prevent leakage through the fabric-attached points. Recycled Polyester88% Spandex12% single jersey fabric is used for the body fabric for this undergarment which aligns with SGDs to improve the sustainability of this product.

A pad (Fig. 1) is developed for improving the absorbency as an extra absorbency layer using cotton polyester blended jacquard terry structured fabric and cotton polyester blended modified waffle structured fabric. The jacquard terry structured fabric was the inner side of the pad and six layers of modified waffle structured fabrics were attached to it as the absorbency layers. It is also bonded using V-fold water retention bonding tapes to ensure the leakproof ability.

B. Design and Develop fabric materials for gusset construction to achieve high absorbency and less bulk.

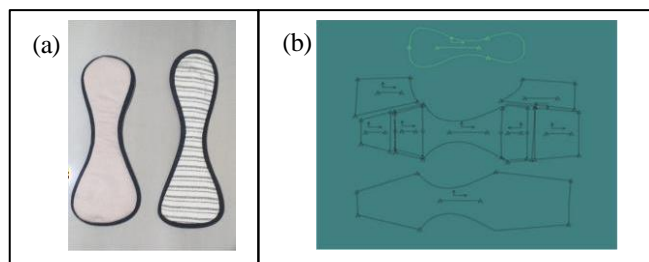


Fig.1. (a)Pad construction (b)Marker of the undergarment – Gerber Accumark technology

TABLE I. FABRIC COMPOSITION OF SPACER FABRIC

Fiber types	Fabric Composition	
	Cotton	Polyester
Weight Percentage	70%	30%

Garment design is created using Gerber Accumark Software (Fig. 1. (b)) for the medium size scale of females according to the Uniqlo standard. The Gusset area is produced by bonding the developed spacer knitted fabric and PU-coated polyester fabric.[6] A 10-gauge flatbed knitting machine is used to knit this spacer fabric, the knitted structure affects the fabric performance such as high absorbency and less bulk of this innovative fabric. The fabric composition of spacer fabric is shown in the table below according to the weight percentage.

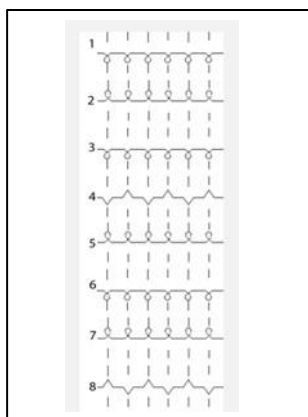


Fig.2. Knitting structure of spacer fabric

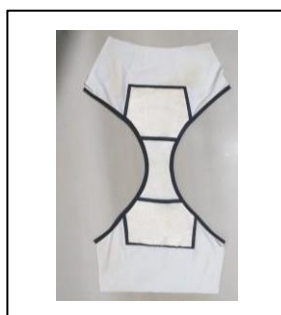


Fig. 3. Inner side appearance of the urine leak proof underwear after bonding the gusset area.

C. Design an undergarment to provide the required functionality of urine leakproof underwear and verify its functionality.

After designing the patterns, this prototype undergarment was developed, and attached the pattern pieces using the bonding technology to ensure leakproof protection. This seamless garment construction improves the comfortability of the consumers and enhances the quality of this product. The maximum absorbency capacity was tested according to the AATCC TM201. The functionalities were also tested according to the AATCC test standard and verified its functionalities of high absorbency, breathability, less bulkiness, and wicking properties.

III. RESULTS AND DISCUSSION

1) *Results of spacer fabric testing:* 0.9% Saline solution was prepared to represent the urine for the proceeding test. The drop test was done using that 0.9% saline solution, with measuring time taken to absorb a drop of saline on the fabric. The average time taken to absorb a drop was 0.46 seconds, which is less than 60 seconds. Therefore, this spacer fabric has a better absorbency capability, according to the AATCC TM 79. An extra absorbency pad was developed to absorb more volume of urine if it has occurred a heavy flow leakage. It depends on the person, then she can decide whether this pad needs to be used or not with this undergarment. This urine leakproof undergarment is designed with pockets and this undergarment can be worn without the pad or with the pad according to the consumer's choice. The wicking ability of the spacer fabric was tested according to the AATCC method. Horizontal wicking and vertical wicking were passed according to the test method[4]. Also, the details of this innovative fabric are as follows in Table III.

TABLE 0. FABRIC DETAILS OF INNOVATED SPACER FABRIC

Testing data	Reading
GSM	470 GSM
Thickness	1.5mm
Composition	70% Cotton, 30% Polyester
CPI	31
WPI	17

2) *Bonding test results:* Tape bonding is selected to continue bonding with 2 mil, 8 mm width Bemis3412 adhesive tapes for bonding the pattern pieces. Water-repellent V-fold elastic 2 mil, 16 mm width Bemis3412 tape is used for bonding the leg curve of the urine leakproof undergarment. A flat press machine was used for bonding at 180°C temperature under 4 bar pressure for 24 seconds. These parameters were finalized by trial-and-error method.

3) *Leakproof ability of the gusset area:* The Polyurethane film-coated polyester fabric ensures leakproof protection by its coating and the leakproof ability is enhanced by the bonding techniques that were used in the undergarment development. MMT test was done for a sample of the gusset area and the test results show that the bottom side was not wet. Water-repellent V-fold bonding tape is used to bond around the guest area, it also enhances the leakproof protection through the edges of the gusset.

4) *Maximum absorbency capacity of the finished undergarment Results:* According to the AATCC TM201, the maximum absorbency capacity of the undergarment without a pad was 84 ml and it was 182ml after adding the pad[7]. The thickness of the gusset area was 2mm and it can be considered as a less thickness. However, it has a 7.3 mm thickness of the gusset of the undergarment with a pad.

According to the requirement of the consumer, she can decide whether this urine leakproof undergarment should be worn with a pad or without a pad as per the above results. If

a consumer has light bladder leakage, she can use this urine-leakproof undergarment without a pad. It is easy to wear, has less bulk, and is comfortable for the consumer. However, for consumers who are suffering from heavy urine leakages, this undergarment with pad option is suitable to use because its main requirement is leakproof protection.

IV. CONCLUSION

The development of reusable urine leak-proof underwear shows a significant advancement in addressing the challenges suffered by individuals with urinary incontinence. This innovative undergarment combines high absorbency, quick-drying properties, and less bulk, achieved using a specialized cotton-polyester spacer fabric and advanced bonding techniques. The research demonstrates that the undergarment can manage different levels of leakage, providing options for consumers based on their specific needs whether they require a pad for heavier leakage or prefer a more user-friendly option without a pad.

The testing results show the leakproof capabilities of the urine leakproof undergarment, with the polyurethane-coated polyester fabric and water-repellent bonding tape enhancing protection in the gusset area. The seamless construction not only improves comfort but also ensures durability and leakproof protection, meeting the essential requirements of breathability, elasticity, and reusability.

This study highlights innovative textile solutions to improve the quality of life for those affected by urinary incontinence, fulfilling the consumer requirements for better performance, and comfortable, and reusable undergarments. Future developments may focus on further enhancing the properties and exploring additional design features to improve this product for a broader range of consumer preferences.

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