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HİJYENİK PEDLERDE FARKLI İÇ KAT TASARIMI VE ÜST KATMAN KULLANIMI İLE SIVI DAĞILIMI VE TEKRAR ISLANMA PERFORMANSININ İNCELENMESİ

INVESTIGATION OF FLUID DISTRIBUTION AND REWET PERFORMANCE WITH THE USE OF DIFFERENT INNER LAYER DESIGN AND TOP SHEETS IN SANITARY NAPKINS

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INVESTIGATION OF FLUID DISTRIBUTION AND REWET PERFORMANCE WITH THE USE OF DIFFERENT INNER LAYER DESIGN AND TOP SHEETS IN SANITARY NAPKINS

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ABSTRACT: Disposable hygienic products are classified as technical textile products and are used intensively in the field of medical textiles. As a hygienic textile product, a sanitary napkin consists of a top sheet, an inner layer (Acquisition Distribution Layer (ADL) and a core of Pulp/Superabsorbent mixture), and a back sheet. Nonwovens are commonly used in the production of these components. The most important factors to consider in new product design are rapid absorption of menstrual fluid, comfort, and also price. In this context, although there is a cost restriction on sanitary napkins, it is clear that the use of different new raw materials and methods will improve their performance characteristics. In this study, a new designed airlaid composite nonwoven combined with synthetic fiber and wood pulp was used as the inner layer of a sanitary napkin without the core. In addition, four different top sheet types were used in the sanitary napkin design. Liquid strike through time, rewet, and menstrual fluid diffusion of the samples were determined, to compare the performance of sanitary napkins with core and without the core. It was concluded that the inner layer design has a significant effect on the liquid strike through time and menstrual fluid diffusion properties. It has been revealed that the menstrual fluid diffusion value of airlaid composite nonwoven sanitary napkins is higher than the ADL+core inner layer. In addition, it was concluded that the top sheet type did not have a statistically significant effect on liquid strike through and rewet properties.

Key words: sanitary napkins, acquisition distribution layer, top sheet, core material, airlaid composite nonwoven.

HİJYENİK PEDLERDE FARKLI İÇ KAT TASARIMI VE ÜST KATMAN KULLANIMI İLE SIVI DAĞILIMI VE TEKRAR ISLANMA PERFORMANSININ İNCELENMESİ

ÖZ: Tek kullanımlık hijyenik ürünler teknik tekstil ürünleri olarak sınıflandırılmakta ve medikal tekstiller alanında yoğun olarak kullanılmaktadır. Hijyenik bir tekstil ürünü olarak, bir hijyenik kadın pedi, bir üst tkatman, bir iç katman (Alıcı ve Dağıtıcı Katmanı (ADL) ve bir Odun Hamuru/Süper emici karışımından oluşan öz) ve bir alt katmandan oluşmaktadır. Bu bileşenlerin üretiminde dokunmamış kumaşlar yaygın olarak kullanılmaktadır. Yeni ürün tasarımında göz önünde bulundurulması gereken en önemli faktörler adet sıvısının hızlı emilimi, rahatlık ve ayrıca fiyattır. Bu bağlamda, hijyenik pedlerde maliyet kısıtlaması olsa da farklı yeni hammadde ve yöntemlerin kullanılmasının performans özelliklerini iyileştireceği açıktır. Bu çalışmada, öz katmanı olmadan bir hijyenik kadın pedinin iç katmanı olarak sentetik elyaf ve odun hamuru ile birleştirilmiş yeni tasarlanmış airlaid kompozit dokusuz yüzey kullanılmıştır. Ayrıca hijyenik ped tasarımında dört farklı üst katman tipi kullanılmıştır. Hijyenik pedlerin performansını özlü ve öz olmadan karşılaştırmak için numunelerin sıvı emme süresi, tekrar ıslanma ve adet sıvısı yayılımı belirlenmiştir. İç katman tasarımının, sıvının emme süresi ve adet sıvısı yayılım özellikleri üzerinde önemli bir etkiye sahip olduğu sonucuna varılmıştır. Airlaid kompozit nonwoven yüzeylerde hijyenik pedlerin adet sıvısı yayılım değerinin ADL+öz iç katmana göre daha yüksek olduğu belirlenmiştir. Ek olarak, üst katman tipinin sıvı emme süresi ve tekrar ıslanma özellikleri üzerinde istatistiksel olarak anlamlı bir etkisinin olmadığı sonucuna varılmıştır.

Anahtar Kelimeler: Hijyenik kadın pedi, Alıcı dağıtıcı katman, Üst tabaka, Öz malzeme, Airlaid kompozit Dokusuz yüzey.

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1. INTRODUCTION

Throughout history, people have used textile fabrics containing various materials such as cotton, linen, to keep the urine and stool of babies under control. Women, on the other hand, tried to absorb the blood coming from their menstrual period with cotton, wool balls, finely chopped moss, corn leaves, animal skin, and pieces of cloth or tree bark. At the end of the 1880s, Franklin used to stop excessive bleeding on the battlefield, began to be used by women as the first disposable pads . However, the high prices of the pads that started to be produced prevented widespread use. In 1930, several textile companies began experimenting with bondable materials to evaluate cotton waste. The first commercial production, called nonwoven, was carried out in the United States with an effort to produce fabric directly from fiber. Parallel to this situation, modern baby diapers and sanitary napkins were introduced between 1940-1960 and mass production began. The development of technology has reduced mass production costs and the demand for disposable products has increased rapidly [1].

In order to adapt to today's intense and fast conditions, technology and consumer products offer us the fastest and most practical solutions. Disposable hygienic products constitute a large part of the products that we consume very quickly in our lives. The main hygienic products included in the medical products are; surgical gowns, masks, adult diapers, feminine sanitary napkins, baby diaper, bed pads etc. Since these products offer a lot of variety to the users in terms of skin compatibility, health, hygiene and comfort compared to traditional products, they have expanded their usage areas. Especially in feminine sanitary napkins, where comfort is at the forefront, pads of different lengths and widths have started to be demanded according to the amount of liquid and the usage position.

Sanitary napkins have a high consumption rate level in the market for hygiene products. Since every woman has menstrual bleeding during her fertile periods. Considering that at least half of the world's population is women, the importance of this sanitary napkins market is clearly understood. The global sanitary napkins market was valued at USD 16400 million in 2020 and is expected to reach USD 22000 million by the end of 2027 [2]. Typical sanitary napkin consists of top sheet, inner layer (Acquisition/Distribution Layer-ADL and absorbent core (Pulp/Superabsorbent mix)) and a back sheet. Top sheet allows absorbing the menstrual fluid quickly; ADL is responsible for spreading the incoming menstrual fluid throughout the bottom layer; absorbent layer (core) provides the liquid holding and absorption; back sheet is made of liquid-proof layer that allows no leakage [3-4]. ADL and absorbent core layers are formed by different nonwoven fabric production methods. The requirements for non-woven fabrics in the field of feminine hygiene products have increased continuously over the years. In many feminine hygiene applications, the special design capabilities of nonwovens have greatly benefited [5]. The basic requirements of sanitary napkins are to absorb and retain menstrual fluid, stop leaks, provide an aesthetic appearance, prevent odor, stay in place and provide a feeling of comfort [6].

There are many studies in the literature to improve the properties of different layers that make up sanitary napkins. Dhinakaran *et. Al* designed a comfortable and breathable sanitary napkins using lyocell and modal at different blend ratio (100% lyocell, 100% modal and 50%/50% lyocell/modal) as absorbent core layer. They found that more co-friendly and sustainable regenerated fibers (lyocell and modal) can be used as alternative instead of wood pulp [6]. Reshma *et.al* developed membranes that can be cost-effective degradable alternative to commercial polyacrylate-based nonbiodegradable sanitary products. Eco-friendly biopolymers of NaCMC and starch via two commercially viable membrane fabrication techniques were developed as superabsorbent core material [7]. Mishra *et.al* studied to reduce sanitary napkins cost by using flax, carding waste fiber as absorbent core. They treated core sheet with methenolic extract of Aloevera gel. The alternative absorbent layer was found to meet all requirements of sanitary napkin performance [8]. Kumar *et.al* studied the moisture behaviour of sanitary napkin using natural fibers as core absorbent layer. For this purpose, milkweed fibers blended with cotton at different ratios were used to develop sanitary napkins. They found that increasing milkweed fiber blend ratio enhanced moisture properties [9]. Petchimuthu *et.al* offered cost effective, biodegradable, and eco-friendly sanitary napkin consisting of banana and cotton fiber [10]. Banappagoudar *et.al* designed 100% organic sanitary napkin including banana fiber, cotton fiber, neem powder and oil cloth [11]. Liu *et.al* studied an absorbent sheet based on flax yarn waste under different synthesis conditions, which is environmentally friendly, low cost, and super absorbent [12]. Hassan Shibly *et.al* designed six models using various biopolymers (cotton, viscose, wood pulp, sodium alginate and carboxy methyl cellulose (CMC) in different ratios as the core absorbent layer) as an alternative for sanitary napkin. They found that the use of sodium alginate and CMC can be replaced with super absorbent polymer [13]. Sathiskumar *et.al* investigated on biodegradable absorbent material with cotton waste material and natural extract based anti-bacterial nanocolorants suitable for sanitary napkins [14].

The main purpose of the studies is to offer a cost effective absorbent layer alternative. In addition to the natural alternatives offered, we see that there are synthetic alternatives as well. However, the commercial feasibility of alternatives presented as absorbent layers is limited. This allows the exploration of different alternative sources. This study is about presenting a new alternative inner layer design, which is an innovative airlaid composite nonwoven fabric under patent examination, consisting of synthetic fiber and wood pulp. Sanitary napkins of airlaid composite nonwoven inner layer were designed at four different top sheets and commercial use sanitary napkins (control groups) with these different top sheets were also combined in order to compare the liquid strike through, rewet, and menstrual fluid diffusion properties statistically.

2. MATERIAL AND METHOD

Four different commercially used top sheets were chosen for this study and photographic views are represented in Figure 1. The properties of the top sheets are given in Table 1. The ADL layer, which helps to disperse the incoming liquid, is formed by bringing the fibers together and bonding them with heat. Standard hygienic sanitary napkin products, liquid comes to the core layer, which consists of super absorbent particles and wood pulp, and is absorbed and trapped in this area. Both ADL and absorbent core are in inner layer of the sanitary napkins. In this study, newly designed and developed airlaid composite nonwoven with synthetic fiber and wood pulp was used as inner layer of sanitary napkins. Airlaid composite nonwoven used in basis weights 208 gr/m² and thickness 1.97 mm.

Design of experiment is shown in Table 2. Totally 8 different sanitary napkins were combined with layers given in Table 2 as inner layer design parameter.

Table 1. The properties of top sheets used for sanitary napkins

Top Sheet	Raw Material	Weight (gr/m²)	Machine Direction Strength (N)
(1) PE Perforated Fabric-1	Polyethylene	21	16.7
(2) PE Perforated Fabric-2	Polyethylene	16	15.24
(3) Spunbond PP Nonwoven+Laminated PE Film	Polypropylene+ Polyethylene	20	27.2
(4) Spunbond PP Nonwoven	Polypropylene	18	39.48

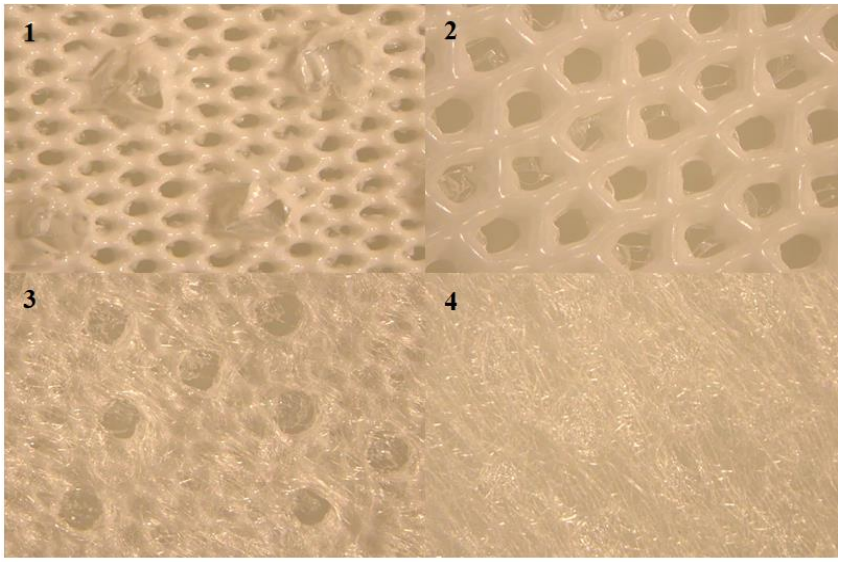

Figure 1. Top sheets used for sanitary napkins; Top Sheet Type (1) PE Perforated Fabric-1, (2) PE Perforated Fabric-2, (3) Spunbond PP Nonwoven+Laminated PE Film, (4) Spunbond PP Nonwoven

Table 2. Design of experiment

Independent Variables		**Response Variables**
Inner Layer Design	**Top Sheet Type**	
Top Sheet ADL Absorbent Layer (Core) } Inner Layer Back Sheet **ADL+CORE**	(1) PE Perforated Fabric-1 (2) PE Perforated Fabric-2 (3) Spunbond PP Nonwoven+ Laminated PE Film (4) Spunbond PP Nonwoven	Liquid Strike Through Time (sec) Rewet (gr) Menstrual Fluid diffusion (mm)
Top Sheet Airlaid Composite Nonwoven } Inner Layer Back Sheet **AIRLAID COMPOSITE NONWOVEN**		

The ability of a disposable absorbent pad to keep the wearer's skin dry during use is an important performance characteristic. This feature is often referred to as "rewet". To test this feature, a certain amount of low-viscosity menstrual fluid is given to the pad and a weight is placed on it to measure the dry-keeping ability of the surface [15]. An apparatus with an open middle part is placed on the pad and a certain amount of menstrual fluid is poured from it (Figure 2). The spilled menstrual fluid is waited until it is completely absorbed on the surface and the time it absorbs is noted. After waiting for a while, a pre-calculated special absorbent reference paper is placed on it and weight is placed on it. This test clearly simulates the condition of a woman sitting on a wet pad. After waiting under the weight for a certain period of time, the reference paper is weighed again and the amount of liquid left by the fabric is calculated. The same steps are repeated by giving liquid to the same sanitary napkin three times in total. In this way, the performance of the pad, which has been flooded several times, is checked. At the end of the rewet test diffusion of the menstrual fluid is determined by measuring the length at which the menstrual fluid spreads and recording in mm.

To analyse the importance of inner layer design and top sheet type on liquid strike through time (sec), rewet (gr) and menstrual fluid diffusion (mm) statistical analysis was carried out at 95% confidence interval using Minitab™ 18 package program.

3. RESULTS AND DISCUSSION

3.1. Liquid Strike Through Time and Rewet

Interaction plots for liquid strike through time for top sheet and inner layer design on sanitary napkins are illustrated in Figure 3.

The most important feature expected from the top sheet is to ensure rapid transfer of the liquid to the substrate. The fastest fluid transfer is seen in sanitary napkins with PE Perforated Fabric-1 (21 g/m^2) top sheet with ADL+Core inner layer. It was determined that airlaid composite nonwoven sanitary napkins transferred liquid to the substrate in a longer time in all top sheets. It is seen that spunbond PP nonwoven top sheet with airlaid composite nonwoven inner layer sanitary napkin have the slowest rate of liquid transfer to inner layer. It was determined that liquid strike through time of sanitary napkins with ADL+core inner layer was lower than sanitary napkins with airlaid composite nonwoven inner layer. As seen in the Table 3, top sheet type does not have a statistically significant effect on liquid strike through time (p>0.05). On the other hand, the inner layer parameter has a statistically significant effect on liquid strike through. It was found that the top sheet type and inner layer interaction did not have a significant effect on the liquid strike through time feature.

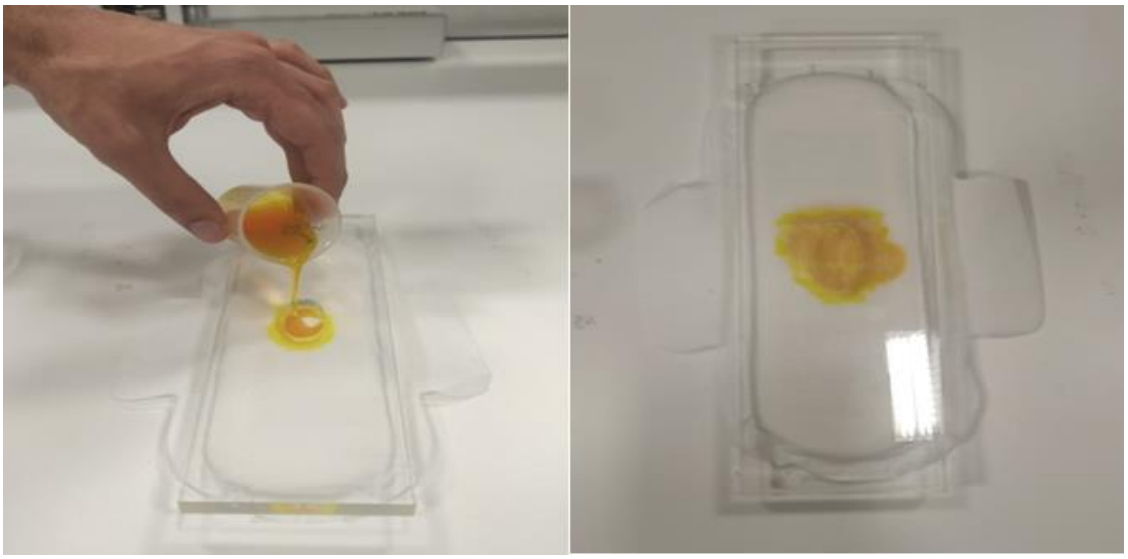

Figure 2. The execution of the experiment

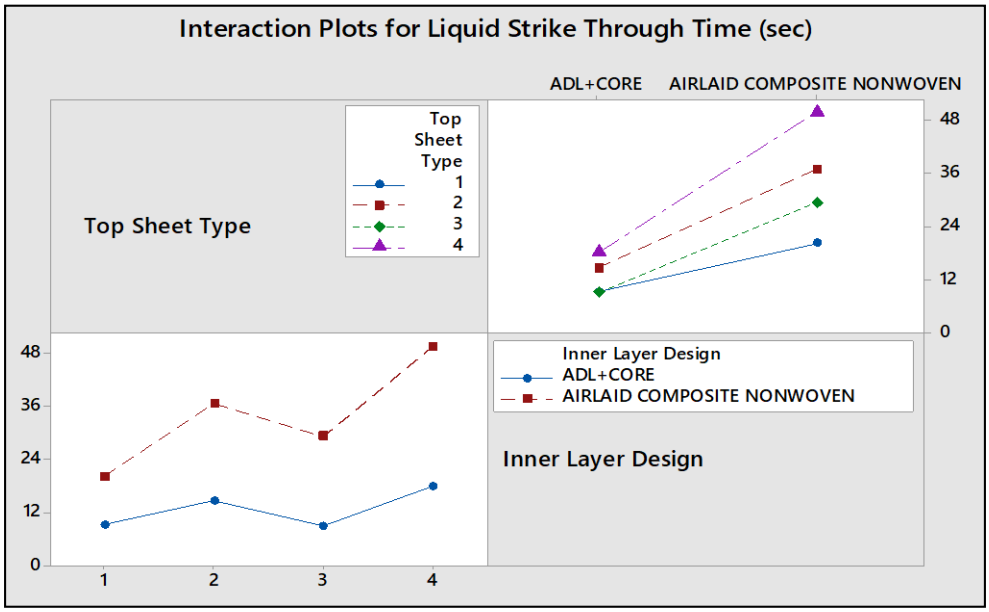

Figure 3. Interaction plots for liquid strike through time; (1) PE Perforated Fabric-1, (2) PE Perforated Fabric-2, (3) Spunbond PP Nonwoven Laminated PE Film, (4) Spunbond PP Nonwoven

Table 3. Analysis of variance analysis for liquid strike through time, rewet and menstrual fluid diffusion

Independet parameters/ Response variables	**Top Sheet Type (A)**	**Inner Layer Design (B)**	**A*B**
Liquid Strike Through Time (sec)	0.228	**0.005***	0.743
Rewet (gr)	0.733	0.285	0.691
Menstrual Fluid Diffusion (mm)	**0.000***	**0.000***	**0.000***

***Statistically significant at 0.05 significance level.**

A low rewet value indicates that sanitary napkins have a low rewet feature, that is, a good performance. The interaction plots for inner layer and top sheet type shows that sanitary napkin rewet value with Perforated Fabric-2 top sheet and airlaid composite nonwoven inner layer was determined as the lowest among all samples (Figure 4).

In general, it is seen that the rewet value is lower in sanitary napkins with ADL+Core inner layer. This means that the absorbent core layer traps the menstrual fluid well. However, the rewet difference between ADL+Core sanitary napkins with airlaid composite nonwoven sanitary napkins varies between 0.76 gr and 1.35 gr. This difference is considered to be low. As a matter of fact, Table 3 shows that there is no significant difference between top sheet type (A), inner layer design (B) and A*B on the rewet feature (p>0.05).

3.2. Menstrual Fluid Diffusion

The interaction plots for menstrual fluid diffusion properties of sanitary napkin samples are shown in Figure 5. A high value means that the menstrual fluid spreads better within the inner layer. The highest menstrual fluid diffusion was observed in sanitary napkin with airlaid composite nonwoven inner layer and PE Perforated Fabric-2 top sheet (Figure 5). Considering the top sheet variable, it was determined that the highest menstrual fluid diffusion was in PE Perforated Fabric-2 and the lowest menstrual fluid diffusion was in sanitary napkin samples with Perforated Fabric-1 top sheet. It was concluded that sanitary napkins with ADL+Core inner layer have low menstrual fluid diffusion property. According to the analysis of variance results given in Table 3, top sheet type and inner layer design and interaction of these parameters were found to have statistically significant on menstrual fluid diffusion property (p<0.05).

4. CONCLUSIONS

In this study, newly developed airlaid composite nonwoven was used as inner layer of the sanitary napkins. In this way, it was aimed to offer an alternative to commercially used sanitary napkins. For this purpose, sanitary napkins samples with ADL+Core and airlaid composite nonwoven inner layer were obtained by using four different top sheets. Liquid strike through, rewet and menstrual fluid diffusion properties of these samples were determined. The findings obtained as a result of the study are listed below;

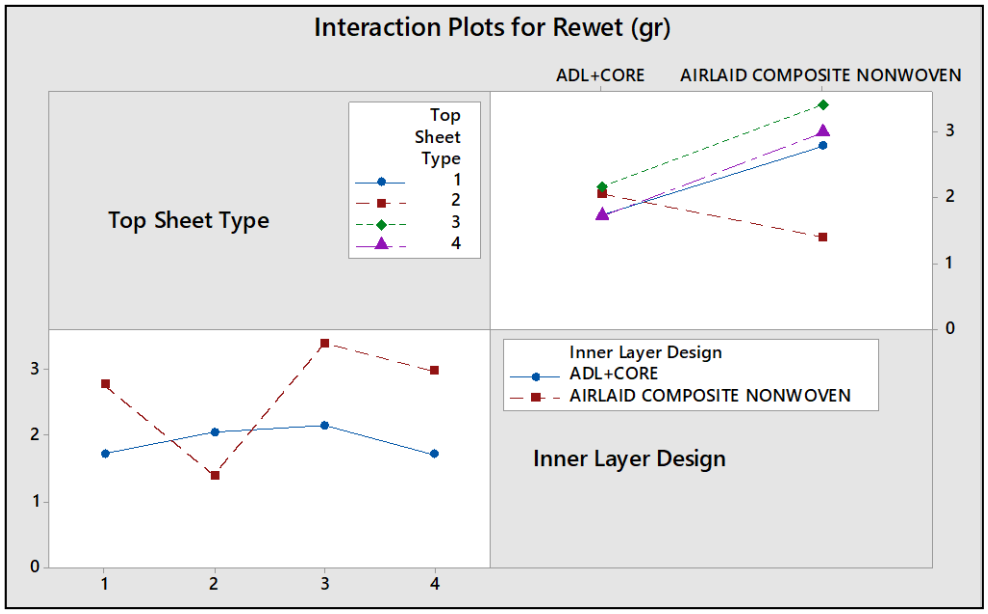

Figure 4. Interaction plots for rewet in weight; (1) PE Perforated Fabric-1, (2) PE Perforated Fabric-2, (3) Spunbond PP Nonwoven Laminated PE Film, (4) Spunbond PP Nonwoven

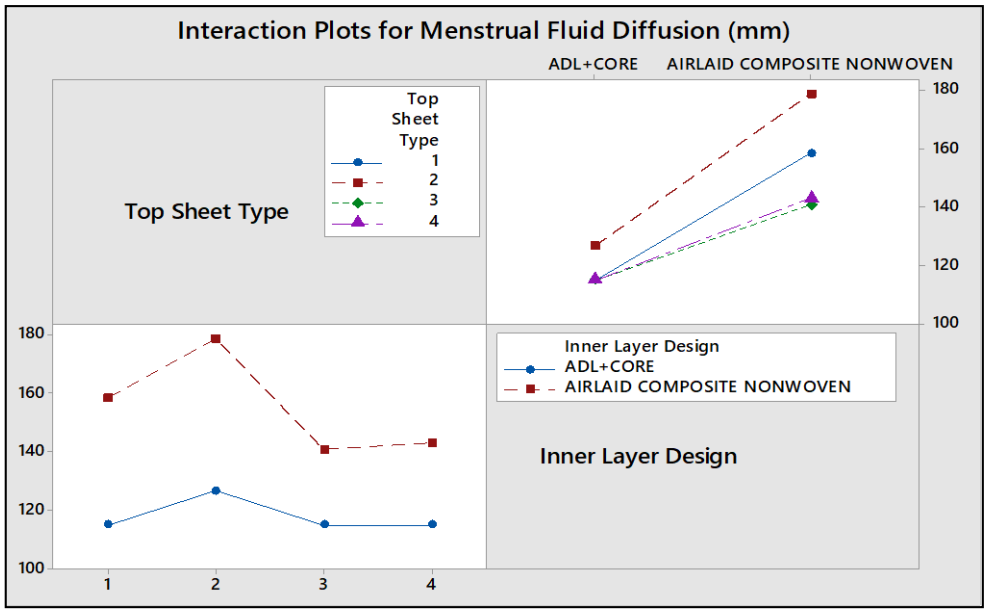

Figure 5. Interaction plots for menstrual fluid diffusion; Top Sheet Type (1) PE Perforated Fabric-1, (2) PE Perforated Fabric-2, (3) Spunbond PP Nonwoven Laminated PE Film, (4) Spunbond PP Nonwoven

- Results show that sanitary napkin with airlaid composite nonwoven inner layer have higher liquid strike through time, rewet and menstrual fluid diffusion than sanitary napkins with ADL+Core inner layer. On the other hand, there is no statistical difference between these two inner layers in terms of rewet. In addition, sanitary napkin with airlaid composite nonwoven inner layer indicates higher menstrual fluid diffusion properties. In conclusion, airlaid composite nonwoven inner layer can be a good alternative to ADL+Core inner layer if the liquid strike through time is reduced. However, this study supports new studies to reduce liquid strike through time.
- It was determined that the top sheet variable did not have a statistically significant effect on the liquid strike through and rewet properties. Based on this finding, it was concluded that the most suitable top sheet type sanitary napkin can be chosen in terms of price.

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