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Development of nonwoven under pad using cotton and flax fiber blend

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Abstract - The increasing emphasis on sustainability has stimulated research into the utilization of natural fibre composites in medical applications. This project seeks to enhance absorbency, comfort, and biodegradability by developing a nonwoven under pad utilizing mixes of cotton and flax fibres, while preserving necessary functional performance. Flax fibres were chosen for their superior moisture retention, inherent antibacterial capabilities, and environmentally sustainable characteristics, and cotton offers softness and absorbency. Three blend ratios were formulated: sample 1 (60:40), sample 2 (50:50), and sample 3 (70:30) of cotton to flax. The fibres underwent regulated opening, carding, and web creation, subsequently followed by needle punching to create the nonwoven structure. The samples were assessed for base weight, thickness, absorbency, wicking behaviour, tensile strength, and biodegradability. The results indicated that cotton-flax blends provide superior mechanical strength, enhanced moisture management, and ecological advantages over synthetic under pads, underscoring their viability as sustainable alternatives.

1. INTRODUCTION

To lessen its influence on the environment, the textile sector has demonstrated a rising interest in creating eco-friendly and sustainable products in recent years. Due to their adaptability, affordability, and capacity to be used in a variety of applications, including medical, hygienic, and protective items, nonwoven fabrics have become increasingly important. Because of their protecting and absorbent qualities, under pads are very popular in the personal care and healthcare industries. Under pads are typically composed of synthetic fibres like polyester and polypropylene, which are effective yet non-biodegradable and environmentally problematic. Because natural fibres are renewable, comfortable, and biodegradable, using them to get around this restriction has grown in popularity. The goal of this research is to create a nonwoven under pad by combining flax and cotton fibres. While flax offers strength, durability, and improved moisture control, cotton offers softness, absorbency, and comfort. The goal of the project is to develop a sustainable under pad with useful mechanical and absorbent qualities by merging these two natural fibres. Preparing the fibre blend, making the nonwoven fabric, and assessing its main performance attributes are all part of the job. The project's goal is to show that natural fibre-based nonwovens may function as a practical and environmentally responsible substitute for synthetic under pads in applications related to hygiene and healthcare.

2. Materials used

Cotton- Cotton is extensively utilized in bed under pads largely because of its inherent softness, absorbency, and skin-friendly characteristics. First, cotton has good moisture absorption ability, which helps to swiftly absorb and retain fluids, keeping the surface dry and reducing leaking. This is especially important with under pads, as it helps maintain hygiene and decreases the chance of skin irritation. Secondly, cotton is soft and breathable, facilitating air circulation that keeps the user comfortable even over lengthy hours of usage. Its natural fibers are soothing on delicate skin and lessen the possibilities of rashes or allergies, unlike certain synthetic fabrics. Cotton is very sturdy and can tolerate repeated washing, making it excellent for reusable under pads. Additionally, it is biodegradable and eco-friendly, which makes it a sustainable choice compared to synthetic alternatives. Overall, cotton delivers a combination of absorbency, comfort, safety, and sustainability, making it a great material for bed under pads.

Flax- Flax fibers offer strong moisture absorption qualities, allowing the under pad to quickly take up fluids and keep the surface reasonably dry, which aids in maintaining comfort and hygiene. One of the primary advantages of flax is its inherent strength—linen fibers are significantly tougher than cotton, so under pads manufactured with flax can resist repeated usage and washing without losing their structure. Flax is also very breathable, which encourages air circulation and avoids heat accumulation, making it pleasant for long-term wear. In addition, it contains natural antibacterial and antimicrobial qualities, which help prevent Odor and the growth of bacteria—an crucial element in hygiene products like under pads. Another benefit is that flax dries faster than many other natural textiles, boosting usage and lowering the danger of moisture. Flax is an eco-friendly fibre, as it is biodegradable and uses less water and chemicals to create compared to many other fibres. Because of its strength, breathability, hygienic characteristics, and sustainability, flax is a desirable material choice for bed under pads.

Polypropylene

Polypropylene is commonly utilized in bed under pads due to its great functional qualities. It is lightweight yet sturdy, which helps the pad keep its structure while usage. One of its primary advantages is its hydrophobic nature, meaning it does not absorb liquids and efficiently works as a barrier to prevent leaks onto the mattress. In nonwoven form, polypropylene provides a soft and pleasant surface for the user while yet enabling fluids to move swiftly into the absorbent core beneath. It is also resistant to chemicals and microbiological development, making it sanitary and safe for medical and personal care uses. Additionally, polypropylene is cost-effective and easy to manufacture, which makes it excellent for throwaway items. Its ability to be thermally bonded guarantees exceptional strength without the need for further adhesives. Overall, polypropylene delivers an optimal blend of comfort, protection, durability, and cost in bed under pads.

Polyethylene

Polyethylene is utilized in bed under pads largely for its outstanding waterproof characteristics. It works as the bottom layer of the pad, preventing any liquid from soaking through to the mattress or bed surface. This makes it particularly efficient in preserving dryness and cleanliness, especially in medical and personal care environments. Polyethylene is also flexible and lightweight, allowing the under pad to remain comfortable and simple to handle without increasing rigidity. It has strong chemical resistance, so it does not react with bodily fluids or cleaning chemicals, assuring durability and safety throughout usage. Additionally, polyethylene is cost-effective and easy to produce, making it perfect for disposable under pads. Its smooth surface also assists in simple cleaning and disposal. Overall, polyethylene plays a significant function in establishing a strong moisture barrier, assuring protection, cleanliness, and convenience in bed under pads.

SAP

Super Absorbent Polymer (SAP) is utilized in bed under pads because of its extraordinary capacity to absorb and retain significant volumes of liquid. SAP can absorb several times its own weight and transform the liquid into a gel, which prevents leaking and keeps the surface dry. This feature is vital for preserving comfort and cleanliness, notably in medical and personal care applications. By trapping the fluid within, SAP decreases the chance of skin irritation, rashes, and Odor development. It also helps disperse fluids uniformly within the absorbent core, boosting the overall effectiveness of the pad. Additionally, SAP promotes the thinness of the under pad by decreasing the requirement for bulky absorbent materials like cotton or pulp. This makes the pad lighter and more pleasant to use. Overall, SAP plays a crucial role in enhancing absorbency, dryness, cleanliness, and user comfort in bed under pads. SAP (Super Absorbent Polymer) is usually utilized at roughly 20% to 40% of the absorbent core in bed under pads. Lower ranges (20–25%) are utilized for standard absorbency, whereas higher ranges (30–40%) are used for high absorbency pads to enhance liquid retention and dryness.

Fig -1: Final product

3. RESULT AND DISCUSSION

In this chapter we deal with results obtained from testing the non-woven fabric blend with flax and cotton. Totally 3 ratios were taken, tested and the results are discussed in this chapter.

Weight of the under pad

To determine the mass per unit area of a bed under pad as per IS 1964, the sample is first conditioned at 27 ± 2°C and 65 ± 2% relative humidity. A flat, wrinkle-free sample is then put on a smooth surface, and specimens are cut using a standard GSM cutter (typically 100 cm²). Each specimen is weighed using a precise electronic balance, and the average weight is computed. The value is translated into grams per square meter (GSM) based on the cutter area (e.g., multiplied by 100 for 100 cm²). The final GSM result, derived by averaging many measurements, reveals the under-pad's weight, absorbency, and quality.

Table -1: Weight of the sample

DETAILS OF TESTS	SAMPLE-1	SAMPLE-2	SAMPLE-3
Weight of the under pad (gm)	30.08	30.12	30.04

Under pad dimensions

a. Length and width

At least three under pad samples should be picked at random from the collection. Make sure the pads are: Not wrinkled, crumpled, or deformed not stretched or squeezed Without exerting any pressure, place the under pad flat on the table. To get rid of wrinkles, lightly smooth by hand (don't strain). Maintain a standard environment for the samples: The temperature is 27±2°C. 65 ± 5% relative humidity Prior to testing, condition for at least four hours.

b. Thickness

Sample conditioning27 ± 2°C and 65 ± 5% relative humidity. At least four hours Preparing Samples take three new or identical samples. Make sure: Pads are not crushed or crumpled. No obvious faults.

Table -2: Under pad Dimensions

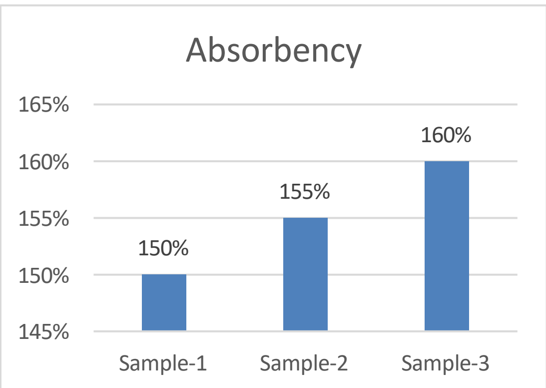
	DETAILS OF TESTS	SAMPLE-1	SAMPLE-2	SAMPLE-3
	Under pad dimension (cms)			
a.	Length	50.21	50.12	50.25
b.	Width	25.56	25.49	25.24
c.	Thickness	1.25	1.26	1.25

Absorbency

On a level surface, place the under pad flat. Mark the pad's middle compute a set liquid volume:50 ml or 100 ml, depending on the demand. Gently pour the liquid onto the middle from a height of about 5 cm. As soon as raining starts, start the stopwatch. Examine the absorption of liquid: When there is no more free liquid on the surface, stop the stopwatch. Note the period of absorption (in seconds). Note as W_1 (grams). Pour liquid gently in little quantities until the pad is thoroughly wet. There is no more absorption (leakage may commence). Give the surplus liquid a minute or two to drain. Use filter paper to lightly clean the surface; do not push aggressively. Weigh the moist pad underneath: Note as W_2 (grams).

Remark-Sample 3 is better than 1&2

Chart-1

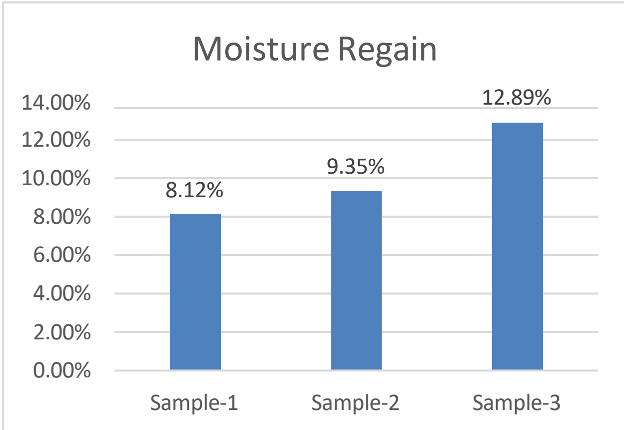


Moisture regain

The moisture recovery of a bed under pad as per IS 199 is measured by first conditioning the sample in a standard environment of 27 ± 2°C temperature and 65 ± 2% relative humidity until it achieves moisture equilibrium. After conditioning, a representative specimen is obtained and its conditioned weight is properly determined using a sensitive electronic balance. The sample is then placed in a hot air oven and dried at a temperature of roughly 105–110°C until it reaches a consistent weight, guaranteeing full elimination of moisture. After drying, the sample is chilled in a desiccator to minimize reabsorption of moisture from the air and then weighed again to determine the oven-dry weight. The moisture recapture is computed as the percentage of the difference between the conditioned weight and the oven-dry weight, divided by the oven-dry weight. This figure represents the moisture absorption capability of the under-pad material.

Remark-sample 3 is better than 1&2

Chart-2

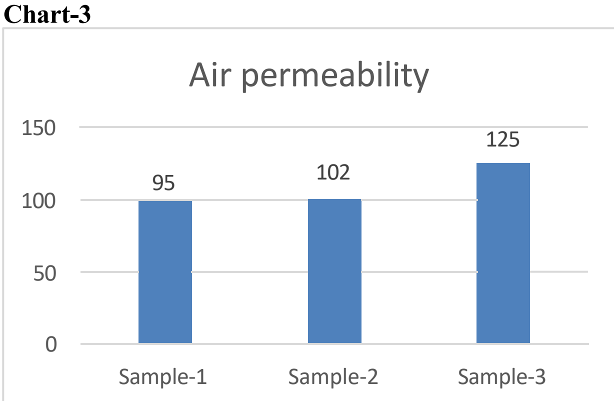


Air permeability

The air permeability of a bed under pad is determined according to ASTM D737 by measuring the rate of airflow flowing through the material under a regulated pressure difference. First, the sample is conditioned in a standard environment (typically 21 ± 1°C and 65 ± 2% relative humidity). A representative specimen is then put firmly in the air permeability tester, ensuring there are no leaks around the edges. The apparatus applies a continuous pressure differential across the cloth, and the rate of airflow going perpendicular through the sample is measured, generally in $cm^3/cm^2/sec$. Multiple measurements are obtained from different regions of the under pad to guarantee accuracy and consistency. The average value is determined and presented as the air permeability of the sample. This test helps evaluate the breathability of the under pad, which is vital for user comfort and moisture vapor transfer.

Remark-sample 3 is better than 1&2

Chart-3



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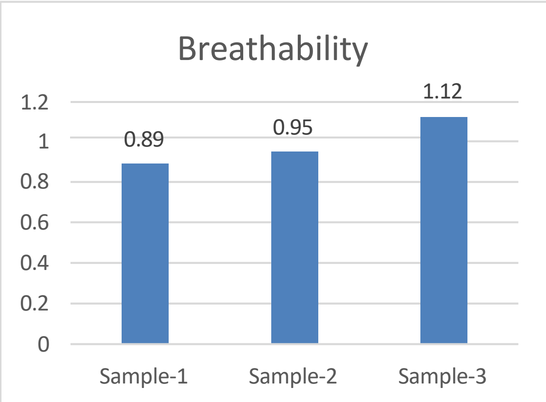
Breathability

The breathability of a bed under pad is examined using the air permeability test as per ASTM D737, which evaluates the flow of air through the material. The under-pad sample is initially conditioned under standard atmospheric conditions, namely at a temperature of 21 ± 1°C and a relative humidity of 65 ± 2%, to guarantee uniformity. A representative specimen is then inserted in the air permeability tester and secured tightly to avoid any edge leaking. The apparatus applies a continuous pressure differential across the sample, allowing air to travel perpendicularly through the cloth. The rate of airflow is measured and recorded in quantities such as $cm^3/cm^2/sec$ or $L/m^2/sec$. Several measurements are collected from different sections of the sample to verify accuracy and uniformity, and the average value is determined. Higher air permeability suggests higher breathability, which adds to increased comfort and moisture vapor transfer in the under pad.

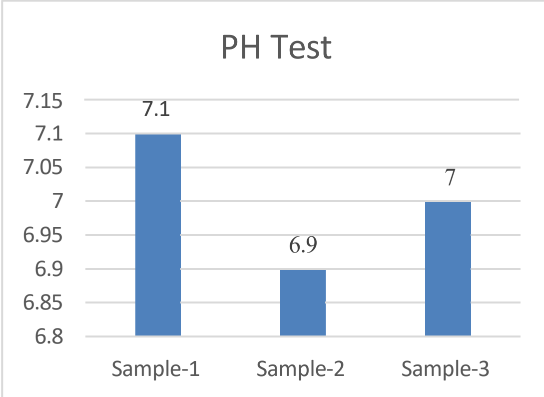
Chart-4



PH Value

The PH of a bed under pad is ascertained in accordance with IS 1390 by extracting soluble chemicals from the sample and evaluating their acidity or alkalinity. The under-pad sample is initially broken into small pieces and subsequently conditioned under regular atmospheric conditions. A measured weight of the sample is thereafter submerged in distilled water, often at a designated liquor ratio, and maintained for a predetermined duration with intermittent stirring to facilitate the dissolution of soluble components. Subsequent to extraction, the solution is either filtered or decanted to yield a transparent liquid. The PH of this extract is subsequently assessed with a calibrated PH meter at ambient temperature. To guarantee precision, several readings may be conducted, and the mean value is provided. This test evaluates the safety of the under pad for skin contact, as severe PH values may induce irritation.
Remark-sample 3 is better than 1&2

Chart-5



Skin irritation

The skin irritation potential of a bed under pad is assessed as per ISO 10993 by producing extracts of the material using an appropriate medium under controlled circumstances. The extract is then administered to the skin of test subjects under ethical laboratory circumstances. The test site is monitored at particular intervals for symptoms of irritation such as redness (erythema) and swelling (edema). These reactions are rated using a conventional scoring method, and a control is utilized for comparison. The findings are recorded, and an irritation index is produced to designate the substance as non-irritating, somewhat irritant, or irritant, confirming its safety for skin contact.

Result:
Sample-1: few irritations found
Sample-2: few irritations found
Sample-3: No itching and irritation found

Tensile strength

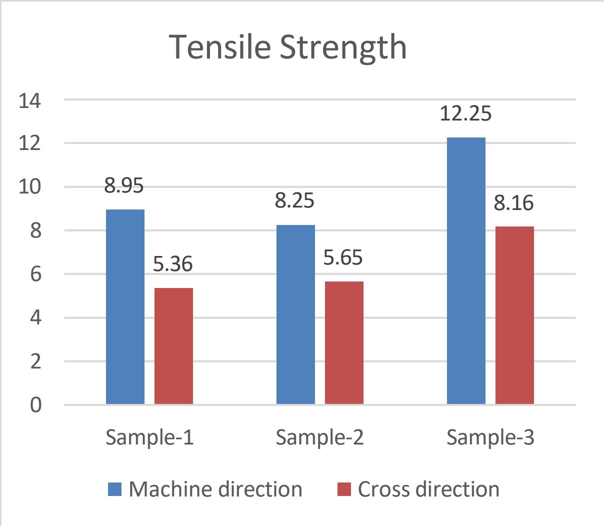
1. Machine direction

The under-pad sample is first conditioned at 21 ± 1°C and 65 ± 2% relative humidity. Specimens are chopped along the machine direction to the necessary size. Each specimen is clamped in the tensile testing machine with a preset gauge length. A steady rate of extension is applied until the specimen breaks. The highest force at break is recorded as the tensile strength in the machine direction. Multiple measurements are obtained and the average value is determined.

2. Cross direction

Similarly, specimens are chopped perpendicular to the machine direction (cross direction). After conditioning, each sample is installed in the tensile tester and stretched at a steady pace until rupture. The maximal force is recorded as the tensile strength in the cross direction. Several readings are obtained, and the mean value is published.

Chart-6



Antimicrobial test

The antibacterial effectiveness of a bed under pad may be assessed using both AATCC 100 and AATCC 147. In the AATCC 100 procedure, the test is quantitative, where a known quantity of bacteria is put onto the under-pad sample. The sample is incubated under controlled conditions for a specific duration. After incubation, the bacteria are collected from the sample and the quantity of surviving microorganisms is assessed by plating and counting colonies. The reduction in bacterial count relative to a control sample is computed to establish the percentage of antibacterial activity.

In the AATCC 147 technique, the test is qualitative and entails putting the under pad specimen on an agar plate that has been equally infected with bacteria. The plate is then incubated, and the sample is inspected for zones of inhibition surrounding it. The existence and width of a clean zone reflect antibacterial efficacy. Together, these assays examine both the degree and existence of antimicrobial activity in the under pad.

Result:

Sample-1: few microbial activities found
Sample-2: No microbial activities found
Sample-3: No microbial activities found

Antifungal test

The antifungal activity of a bed under pad is assessed according to ISO 13629 by examining the material's capacity to resist fungal development. In this method, the under-pad sample is first sterilized and then infected with a known concentration of fungal spores under controlled laboratory circumstances. The infected samples are incubated at a predetermined temperature and humidity for a defined duration to facilitate fungal development. After incubation, the samples are inspected visually and/or microscopically to determine the degree of fungal growth on the surface. In certain situations, the fungus may be retrieved and measured to evaluate the decrease in growth relative to an untreated control sample. The results are given depending on the degree of fungal inhibition or resistance. This test helps verify that the under pad resists fungal infection and maintains cleanliness throughout usage.

Result:

Sample-1: few fungal formation
Sample-2: No fungal formation
Sample-3: No fungal formation

Leakage test

The leakage performance of a bed under pad is assessed according to ISO 9073 by examining its capacity to prevent liquid penetration. In this technique, the under pad sample is first conditioned under standard atmospheric conditions. The specimen is then put on a flat, non-absorbent surface, frequently with a blotting or indicator sheet beneath it to detect any leaking. A defined volume of test liquid (typically water or synthetic urine) is placed over the surface of the pad in a controlled manner. The sample is allowed to absorb the liquid for a set duration. After the absorption time, the bottom of the pad and the blotting sheet are checked for any evidence of liquid penetration. The presence or absence of leakage, together with the extent of moisture, is documented. Multiple tests may be run for accuracy, and the results demonstrate the efficiency of the under pad in avoiding leakage and assuring protection.

Result:

Sample-1: No leakage found
Sample-2: No leakage found
Sample-3: No leakage found

4. CONCLUSION

The creation of a nonwoven underpad with a combination of flax and cotton fibres signifies a notable progress in sustainable hygiene products. This study reveals that natural fibres may efficiently satisfy the functional needs of under pads while lowering environmental impact. Flax gives strength, durability, and moisture control, while cotton contributes softness, comfort, and high absorbency, providing a well-balanced textile appropriate for practical usage. The combination satisfactorily satisfies critical mechanical qualities such as tensile strength and structural stability, combined with efficient fluid management. The results suggest that under pad sample 3 fulfils all the relevant requirements and successfully passes the testing. Furthermore, the use of biodegradable and renewable fibres like flax and cotton gives a distinct benefit over synthetic materials such as polyester and polypropylene, which contribute to environmental contamination. Overall, flax-cotton nonwoven under pads offers a stable and eco-friendly solution, promoting sustainable practices in hygiene and healthcare applications.

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