Development of Eco Friendly Sanitary Products

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2.1 OBJECTIVES OF RESEARCH:

Even though there had been number of studies conducted in developing and improving the hygiene products, it was found that still some more improvements are possible to extend the progress. An in-depth investigation is needed that looks into all aspects, from the raw materials to the features of finished product. Certain natural fibres waste like sisal, bagasse or bananas can be turned into absorbent materials in a number of environmentally friendly ways. The main goal of this study is to find natural materials that can be used to replace synthetic materials used the top sheet, absorbent core, and back sheet the disposable sanitary napkin that are available on the global market. Making sanitary pads more eco-friendly not only lowers their price, but also reduces cutting of trees thereby protecting natural resources and environment.

Unlike conventional textiles nonwoven fabric is good absorbent material for hygiene products there by helps women to stay healthy and hygienic, especially during their periods. During the menstruation there is a regular discharge of blood and mucosal tissue from the inner lining of the uterus through the vagina. Menstruation cycle repeat every 28 to 35 days from childhood until menopause phase. Most women prefer disposable pads generally made up of synthetic polymeric materials and wood fluff. The different absorbent materials used in the sanitary pads, can soak up the uterine waste. The disposed napkins have inherent problem that they don't break down naturally hence pose a threat to the environment. The quantum of this generated waste is so big that it’s a challenge to municipal solid waste management system to smooth functioning of cleanliness. Thus personal hygiene products that are not biodegradable have a significant impact on the environment all over the world.

Consequently, the present research endeavour has been carried out with the intention of enhancing the performance of sustainable sanitary napkins by incorporating the eco-friendly materials. The objective is to design of napkin using natural materials: cotton, silk waste, corn, and PLA nonwoven in top sheet; PBAT and PLA in back sheet; air-laid and corn starch paper with absorbent cores. And analyse the performance characteristics by comparative evaluation of their various properties.

2.2 RESEARCH IN BRIEF:

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 2.1).

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 2.1.

Table 2.1 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.

3.0 CONCLUSIONS AND FURTHER SCOPE OF RESEARCH

3.1 CONCLUSIONS

In the present study total ten types of the sanitary napkins of different categories like Maxi, Ultra-Thin and Skiny-Thin of different sizes of length Large 240 mm and Extra-Large 280 mm have been successfully produced using commercial machine by heat sealing technique as per the BIS standards. The 'Maxi-type' is conventional variety widely in use due to high absorbing capacity owing to more thickness. The other two types are thinner preferred by selective groups due to its aesthetic appeal. Conventional sanitation products use much of synthetic nonwoven fabrics along with wood pulp. The huge consumption of these materials poses the high environmental risk and challenges for the solid waste management systems.

For comparative evaluation of the sanitary napkins, different top sheet materials have been incorporated in its design. The hydraulic characteristics of these materials play an important role in performance of the product and provide comfort to the user. Various biodegradable materials which are ecofriendly and available locally in enormous quantity have been introduced for the napkin manufacture.

3.1.1 Absorbency and Rewet properties

(a) Maxi Napkins

- Large size napkins are comprised of about 55% biodegradable materials and 45% non-biodegradable materials.
- Extra-large size napkins are comprised of about 62% biodegradable materials and 38% non-biodegradable materials.
- Napkins made using spun-bond nonwoven top sheet having hydrophilic nature have better absorbing properties as compared to napkins made from hot-air through

nonwoven or perforated poly sheets. The absorbency rate is about 30% better in 1st cycle and 30 to 40% better in 2nd cycle as compared to napkins made from these other materials.

- Napkin made from hot-air through nonwoven top sheet shows about 7% more efficient in absorbency than that of the napkins made from perforated poly sheets.
- Single and double perforated PE sheet-napkin has exhibited minimum rewet weight and PP-spun-bond napkin has exhibited maximum rewet weight in both the absorbency test cycles.
- The fluid absorbency time character has found better in SNL4 due to its double perforated structure which is made up of polyethylene material as compare to SNL2, which is made up of polypropylene hot air through nonwoven top sheet in both the cycles.
- The double perforated structure top sheet has shown better absorbency than that of single perforated structure top sheet.
- The absorbency time and rewet properties are having similar trend in large size and extra-large sanitary napkins in both the cycles.

(b) Ultra-thin Napkins

- Both Large size and Extra-Large size napkin comprises of about 30% biodegradable materials and 70% non-biodegradable materials.
- The double perforated PE top sheet and laminated top sheet i.e. composite (perforated PE film: PP spun-bond nonwoven) has shown the minimum absorption time in both cycles among the ultra-thin sanitary napkins
- The composite top sheet-sanitary napkin has shown about 18% better absorption efficiency in 1st cycle and 15% better absorption efficiency in 2nd cycle than that of single perforated PE napkin.
- Napkins made of hydrophobic nature of single perforated polyethylene top sheet has shown poor absorption rate of absorption time in the range of 30 s to 45 s. This sample as also exhibited minimum rewet.

(c) Skiny-thin Napkins

- Both Large size and Extra-Large napkins are comprised of 100% natural biodegradable and environmental friendly materials like organic cotton, silk waste and corn-PLA top sheets. The acquisition distribution layer**,** core layer and back sheet also have been made using natural biodegradable polymeric materials.

- Napkin made from the organic cotton spun-lace top sheet has shown much better absorbency properties with the lowest absorption time among all the skiny-thin sanitary napkins in both the cycles of test. It has shown 22% and 8% less absorption time in 1st and 2nd cycle in absorption than that of napkin made using silk waste top sheet. Napkin made of corn-PLA top sheet has shown 14% lower absorption time in 1st cycle and 20% lower absorption time in 2nd cycle than that of silk waste top sheet-napkin.
- Napkin made from the silk waste spun-lace top sheet has shown the highest absorption time among all the skiny-thin sanitary napkins in both the cycles.
- Even though the high hygroscopic character of the materials used in skiny-thin napkins, the blood distribution length shown is highest but nearer to the maxi and ultra-thin sanitary napkins without any leakage.

(d) Overall for all Napkin Types

- The uniform distribution of blood along the length of pad is observed for all samples.
- Post absorption test cycles, no leakage of the fluid is observed.
- The absorption rate has shown the inverse relationship with the rewet values.
- The skiny-thin biodegradable sanitary napkins shown the lowest fluid absorption time, while ultra-thin sanitary napkins have shown the highest fluid absorption time.
- The maxi type sanitary napkins made from single perforated sheet have shown the better rewet property in both the test cycles among all types of the sanitary napkins.

3.1.2 Peel Adhesion

All the sanitary napkins complied with the specified range of peel adhesion strength. Among all the napkins studied, the corn-PLA top sheet napkin has shown the highest peel adhesion strength.

The single perforated PE sheet napkin has also shown comparable peel adhesion strength to silk and corn-PLA napkin. Overall, all the samples have demonstrated above the normal required peel adhesion strength.

3.1.3 Seal Strength

All the sanitary napkins met the specified criteria for seal strength. The most sanitary napkins have seal strength good to very good for the front, back, left, and right sides of the pad.

3.1.4 Adhesive residue

The adhesive residue or degree of stability of sanitary napkin for all large and extra-large sizes is within the standard time limit of three seconds. The adhesive residue property that has

been achieved is safe for the user. The separation of the napkin from the undergarment after use will not result in any distortion or damage.

The corn-PLA skiny-thin sanitary napkin and PP spun-bond maxi napkin have demonstrated longest time of 2.8 s among all the napkins, while the silk waste skiny-thin sanitary napkin has shown a time of 1.54 s, which is the shortest among all the napkins.

3.1.5 pH Test

All large and extra-large size napkins shown pH values well within the standard range of 5.5 to 8 which is considered safe for the user with no discomfort or irritation experience.

The top sheet silk waste corn-PLA skiny-thin napkin has demonstrated the highest pH value of 7.26, surpassing all other napkins. On the other hand, the PP spun-bond and PE double perforated maxi have exhibited the lowest pH value of 6.16 among the napkins.

3.1.6 Costing

i. The costing of maxi large size sanitary napkins vary from 1.24 to 1.53 Rs. per piece, while in the extra-large size, the cost varies from 1.70 to 2.03 Rs. per piece.

ii. In the ultra-thin large size of napkins, the cost varies from 1.88 to 2.07 Rs. per piece, while in the extra-large sizes of napkins; the price varies from 2.22 to 2.43 Rs. per piece.

iii. As for prices, in the biodegradable skiny-thin large size napkins costs between 3.47 and 4.15 Rs. per piece, and an extra-large napkins costs between 4.08 and 4.87 Rs. per piece.

iv. The napkins developed in the present study costs significantly lower as compared to commercially available sanitary napkins. The biodegradable napkins are not significantly costly considering environment benifits.

3.2 FURTHER SCOPE OF RESEARCH

- There is ample of opportunities for research on the effects of disposable sanitary napkins on environment, which present an important risk to environmental sustainability.

- Exploring additional materials and experimenting with different types of nonwovens for replacing the polypropylene and polyethylene top sheets.
- There is potential for further study on the feedback of the developed sanitary napkins.
- Exploring the possibility for developing the creative absorbent structures using the materials developed in this study to explore the new exciting avenue (composite).
- There is potential for exploring the alternative materials to the synthetic super absorbent polymers (SAP) and wood pulp (Fluff) which are not manufactured in India. Both these absorbent raw materials have 70% weightage for making the sanitary napkin. In this research, the replacement for these two existing absorbent materials tried to develop with eco-friendly approach. It is worth to explore further in developing biodegradable/eco-friendly/sustainable new materials.
- Biodegradable period panties can also be explored.

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