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RESEARCH ARTICLE

Use of nettle- polypropylene blended mechanical punched nonwoven textiles in oil spill cleanups

Brindha R and Viju S

Abstract

This study examines impacts of nonwoven textile weight, proportion of nettle/polypropylene fibre blend and needle density on oil absorption, nonwoven textile thickness, and nonwoven textile density. The experimental designs of box-Behnken are employed to prepare the mechanical needle-punched nonwoven textiles. Nettle content, needle density and textile weight are boosted, oil absorption declines. Nonwoven textile fabric offers the largest oil absorption (2200%) due to its 30% nettle content, a lesser amount of fabric weight and lower needle density. The nonwoven fabric thickness reduces as the nettle content rises and the needle density rises. The nonwoven textile thickness reduces as the fabric weight and needle density rise and the nettle level increases. At increasing fabric weights, maximum fabric density is achieved. The highest fabric density is produced by higher nonwoven fabric weight (400 g/m2), nettle content (70%) and needle density (350 punches/cm2).

Keywords: Nettle, Polypropylene, Oil spill, Thickness, Fabric density.

Introduction

Oil/water separation has been a global issue in recent years due to oil pollution brought on by oil spillage accidents and hazardous oily industry water (Diao *et al.,* 2017). Oil spilt above water can be cleaned up using a variety of techniques, such as skimmer, chemical, and bacterial methods (Cheryan and Rajagopalan, 1998; Wang, Cui and Xiao, 2007; Su, 2009). However, these methods take time and are hazardous to the environment. In order to discover a better one, fibrous assemblies are being investigated for their potential for cleaning up oil spills. It has been claimed that fibre assemblies, whether packed or structured, can be used to remove oil that has been spilt over large bodies of water (Rengasamy, Das and Prabakaran, 2011).

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Polypropylene is preferred for oil spill clean-ups because of its benefits, including minimal density, superior bodily and chemical resilience, and oil loving and hydrophobic properties (Wei *et al.,* 2003). The biggest downside of utilizing polypropylene or artificial material is that they do not break down easily, making it difficult to dispose of synthetic oil sorbent pads once used. Many attempts have been made to construct bio-degradable/non bio-degradable nonwoven oil sorbents based on natural fibres and mixes. The oil absorption behaviour of mechanical needle-punched nonwoven textiles from kapok, cotton, milkweed, and polypropylene fibres was studied by Renuka, Rengasamy, and Das (2015).

When compared to polypropylene and cotton nonwovens textiles, kapok and milkweed nonwovens have greater oil absorption and retention capabilities. The nonwoven fabric's porosity was discovered to be an important factor in affecting oil sorption capacity. Nonwoven textiles were made by Lee *et al.* (2013) using polypropylene/kapok mixes of 100/0, 75/25, 50/50, 25/75, and 10/90, respectively. The 50/50 polypropylene/kapok combination has the maximum oil absorption and the minimum density. In a separate study, Lee *et al.* (2014) developed nonwoven textiles made up of polypropylene and kapok/polypropylene (90:10) mixes and compared the oil absorption properties with those of commercial polypropylene material. The oil absorption rate and ability increased in the following order: polypropylene/kapok(10:90)blend > polypropylene > commercial polypropylene.

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Choi (1996) examined the oil absorption abilities of nonwoven pads made from cotton and polypropylene fibres. The results showed that the oil absorption capacity of sorbents comprising needle punched cotton for light crude oil was slightly higher than that of sorbents made solely of polypropylene fibres. Individual bundles of cotton and polypropylene fibres soaked up more oil than needle punched nonwoven textiles made from the corresponding fibres. In addition, when the density of the needlings grew, sorption reduced. Vinitkumar, Parameswaran, and Kendall (2017) examined the oil absorption capability of nonwoven textiles manufactured with low micronaire and high micronaire cotton. The study discovered that low mic cotton substrates had a higher oil absorption abilities than those created with high-micronaire cotton.

Although there have been many recent studies on nonwoven materials, the qualities of polypropylene and nettle combined mechanical needle-punched nonwoven textiles still need to be extensively researched. There is a scarcity of literature on the characteristics of nettle with polypropylene-blended non-woven fabrics for oil sorption applications. When it comes to oil absorption, cloth density and thickness are also crucial considerations. As a result, the oil absorption capability of the nettle and polypropylene combined needle-punched nonwoven was given special attention in this investigation. Oil sorption, the fabric's thickness, and the fabric's density have all been researched in relation to weight of the fabric, the density of needle, and mix ratio (nettle: polypropylene).

Materials and Methods

Materials

The source material for the current investigation is a 1.5 to 2 m filament of Himalayan nettle (*Girardinia diversifolia*). The nettle fibres were chopped into staple fibers of 6.5 cm in length, then manually cleaned and sorted. Fabric samples were made from polypropylene fibre with a fineness and length were 6 denier and 6.5 cm. Table 1 illustrates the bodily characteristics of polypropylene and nettle fibres used in this experiment. The crude oil utilized had a viscosity of 18.5cPs and a 0.912 g/cm3 density.

Experimental Design

Nonwoven samples were made depending on Box and Behnken factorial design for three variables to examine the interaction and individual impacts of nonwoven mass, needle density, and mixed proportion of nettle and polypropylene fabric on oil absorption, nonwoven thickness, and density. Table 2 shows the actual and coded values of three parameters.

Fabric Preparation

The DILO needle punching machine was used to create needle-punched nettle/polypropylene mixed non-woven textiles. The fibres were first opened with a fibre opener, and then they were carded with roller carding. The carded fibres were utilized to prepare the web using a cross lapper. In these cross-lapper webs, random fibre alignment was detected. The Non-woven needle punching machine was used to create the nonwoven fabric from the cross lapper web. By altering process parameters, fifteen distinct textiles were created. Nonwoven weight, needle density, and mix proportions of nettle and polypropylene fibres. The cloth was perforated with a regular needle R332G53012, which has two spikes with a dimension of 15×17×40×3.

Measurement of Oil Absorbency on Nonwoven Fabric

The oil absorption capability of textiles materials were determined using the ASTM F 716-09 standard. To investigate oil absorption, samples were placed in crude oil of wet samples was now determined. The oil absorption was calculated using the following equation:

$$\text{Oil sorption (\%)} = [(W_w - W_d)/W_d] \times 100$$

Wherein, W_w – weight of wet nonwoven fabric
W_d –weight of dry nonwoven fabric,

Measurement of Nonwoven Fabric Thickness

The thicknesses of the textile were determined by means of a WIRA Digital Thickness Tester, as per EN ISO 9073-2(1996) standard. A total of five readings were taken in varied places of nonwoven fabrics.

Table 1: Characteristics of nettle and polypropylene fibres

Properties	*Nettle*	*Polypropylene*
Fibre Length (cm)	6.5	6.0
Fibre Fineness (Denier)	3.94	6
Single Fibre Strength (cN/tex)	62.0	38.3
Fibre specific gravity (g/cc)	1.25	0.91
Elongation (%)	1.6	57.52
Wax content (%)	1.24	-

Table 2: Details of parameters used for the study

S.No	*Parameters*	*-1*	*0*	*+1*
1	Nonwoven fabric weight (g/m^2)	200	300	400
2	Needle density (punches/cm^2)	150	250	350
3	Blend proportion (Nettle: Polypropylene)	30:70	50:50	70:30

Measurement of Nonwoven Fabric Density

Nonwoven Fabric weight and thickness were measured according to ASTM D 5261-92 and EN ISO 9073-2(1996) standards. The following relationships were used to calculate the fabric density:

Fabric density (g/cm^3) = [W/T] x 10^{-3}

Under a pressure of 0.5 kPa, W is the nonwoven textile weight (g/m2) and T is the textile material thickness (mm).

Results and Discussion

The Box and Behnken factorial experimental design shows the values of oil sorption, Nonwoven textile thickness, needle density and blend proportion polypropylene and nettle blended mechanical needle punched nonwoven textile in Table 3. The p-values for three separate variables and the coefficient of multiple correlations and response surface equation are shown in Tables 4 and 5. The r^2 and p-values reveal that the anticipated and experimental values of oil absorbency, nonwoven textile thickness, and nonwoven textile density have a good and significant connection. Using standard statistical software, the contour illustrations (Figures 1-9) were created to visualize the individual and interaction impacts of nonwoven textile weight, needle density, and mixed percentage of nettle and polypropylene combined mechanical needle-punched nonwoven as sorbent material.

Impact of Nonwoven Fabric Weight, Needle Density, and Blend Proportions on Oil Absorbency

A nonwoven textile weight of 400 g/m^2, "Figure 1", demonstrates the influence of needle density and nettle content percentage of nettle–polypropylene blended nonwovens on oil absorption. Figure 1 shows that when the nettle content percentage increases, the nonwoven structure's oil absorbency falls and vice versa. This might be attributed to nettle's lesser oil absorption than polypropylene. This pattern may be found in all fabric weights.

The ability of the nettle–polypropylene blended fabric to absorb oil is determined by two factors: the fibre component and the fabric structure. The nettle fibres' hollow structures and open space provide a vast surface range and storage area to oil liquid adsorption retention.

Oil absorption by nettle fibres were designated by one or more of the processes: adsorption by interlinkage between bodily trapping on the fibre outward through its surface morphology; adsorption by interactions between bodily trapping on the fibre surface via its surface morphology; adsorption by interactions between bodily trapping on the fibre surface across its surface morphology;

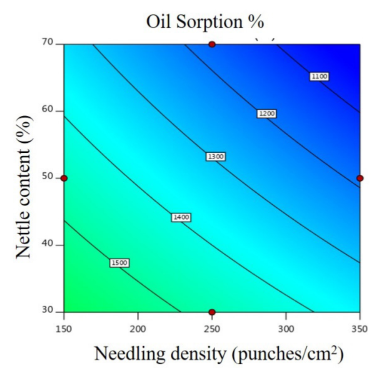

Figure 1: Impact of nettle content and needle density on oil sorbency at 400 g/m^2 level of nonwoven textile weight.

Table 3: box –behnken on oil absorption, thickness, and fabric density of needle punched nonwoven textile

S. No	*Nonwoven Textile weight (g/m^2)*	*Needle density (Punches/cm^2)*	*Ratio proportions (Nettle : Polypropylene)*	*Oil absorption (%)*	*Thickness (mm)*	*Fabric density g/cm^3*
1	200	150	50:50	1604	4.5	0.0632
2	200	350	50:50	1845	3.3	0.0652
3	400	150	50:50	1217	5.0	0.0815
4	400	350	50:50	1442	3.6	0.0971
5	200	250	70:30	2006	2.8	0.0615
6	200	250	30:70	2359	4.0	0.0466
7	400	250	70:30	1046	3.8	0.1156
8	400	250	30:70	1384	4.7	0.1066
9	300	150	70:30	1505	3.7	0.0822
10	300	150	30:70	1988	5.2	0.0552
11	300	350	70:30	1755	3.3	0.0796
12	300	350	30:70	1838	4.2	0.0760
13	300	250	50:50	1727	4.0	0.0809
14	300	250	50:50	1720	4.0	0.0821
15	300	250	50:50	1724	3.9	0.0826

Adsorption by interactions between physical trapping on polypropylene's oil absorption is mostly owing to its oleophilic and hydrophobic properties.

"Figure 2 and 3" illustrate the influence of nonwoven textile weight and needle density on oil absorption of nettle–polypropylene blended nonwoven textiles with 30 and 70% nettle content, respectively. "Figures 2 and 3" show that the oil absorption of the cloth reduces as the fabric weight increases. If the nonwoven fabric weight is raised while the needle density remains constant, the needle barb will have more fibres accessible for needling (Dasai, Jade, and Balasubramanian, 1994). When a result, as fabric weight increases, fabric consolidation increases, reducing oil absorption.

Table 3 further shows that the oil absorbency diminishes as the needling density rises. Better tangling of fibres occurs with increased needling density; as an outcome, nonwoven textile structure becomes more compacted (Debnath and Madhusoothanan, 2014). The compressed nonwoven textile structure has fewer voids, limiting the textiles' ability to store higher oil. Furthermore, the fabric achieves its maximum oil absorption with 30 percentage nettle content, reduced needle density, and less nonwoven textile weight (2200%).

Impact of Nonwoven Textile Weight, Needle Density, and Composition on Nonwoven Fabric Thickness

"Figures 4-6" show the impacts of needle density and nettle percentage on nonwoven textile thickness of a nettle–polypropylene combined needle-punched fabric at 200, 300, and 400 g/m^2 nonwoven textile weight. "Figure 4" shows that when the amount of nettle in the fabric increases, the fabric thickness reduces. This might

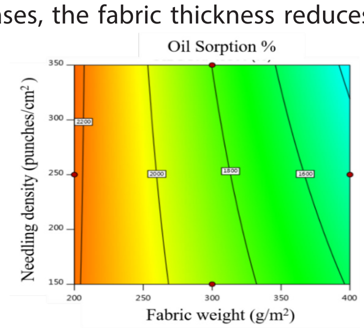

Figure 2: Impact of nonwoven textile weight and needle density on oil absorbency at 30% level of nettle.

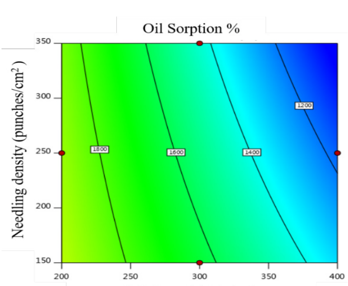

Figure 3: Impact of nonwoven textile weight and needle density on oil absorbency at 70% level of nettle content.

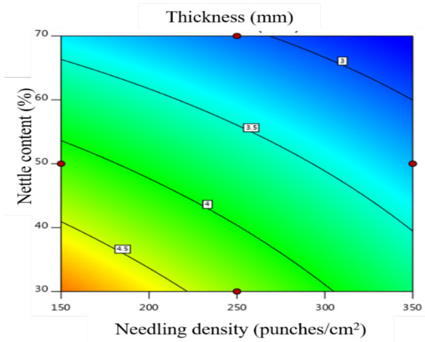

Figure 4: Impact of needle density and nettle content on nonwoven textile thickness at 200 g/m^2 level of nonwoven textile weight

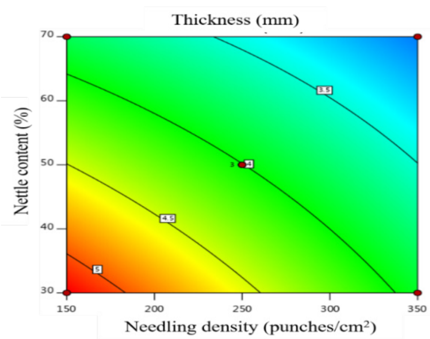

Figure 5: Impact of needle density and nettle level on nonwoven textile thickness at 300 g/m^2 level of textile weight

be because the nettle fibre used in the experiment is finer than the polypropylene fibre (Table 1). As the blend's finer fibre (nettle) increases, the fabric thickness drops. This pattern can be seen at all fabric weights. "Figure 4" further shows that when the needling density increases, the fibre thickness reduces as the nettle content % increases. This might be because increased needling density causes more interlocking of linear polymer fibres due to more condensed textile structure. A similar pattern may be seen at all cloth weight levels (Figures 5 and 6).

Impact of nonwoven textile weight, needle density and mixed composition on fabric density

"Figures 7-9" show the influence of needle density and amount of nettle on nonwoven textile density at fabric weights of 200, 300, and 400 g/m^2. With a lower fabric weight (200 g/m^2), the fabric density rises as the nettle content rises (Figure 7). Because the nettle fiber utilized in the study is finer than polypropylene, the amount of fibers occupied per unit increases, as the nettle content percentage increases, making it easier to achieve a cohesive structure. Fabric weights of 300 and 400 g/m^2 show a similar pattern (Figures 8 and 9).

"Figures 7–9" also show that greater nonwoven fabric weight (400 g/m^2), higher nettle content (70%), and higher needle density (350 punches/cm^2) levels result in increased fabric density. The quantity of nettle fibres occupied per unit area increases as fabric weight and nettle content increase. Under these conditions, the fabric got denser (0.095–0.105g/

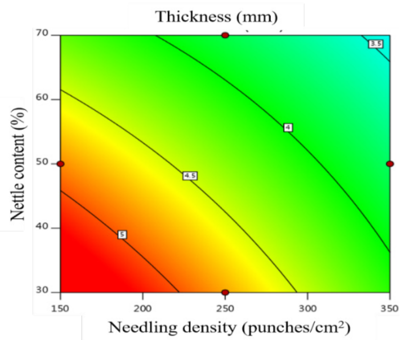

Figure 6: Impact of density of needle and nettle content on nonwoven textile thickness at 400 g/m2 level of textile weight.

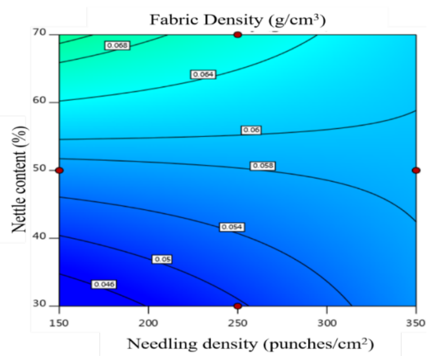

Figure 7: Impact of the density of needle and amount of nettle on nonwoven textile density at 200 g/m² of textile weight.

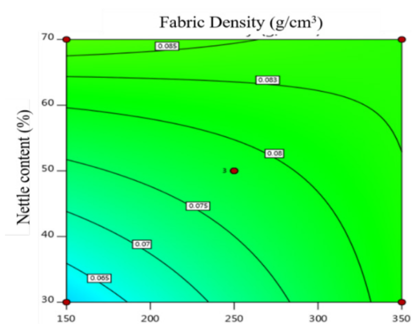

Figure 8: Impact of density of needle and amount of nettle content on nonwoven textile density at 300 g/m² level of fabric weight

cm³) while the needling density was increased from 250 to 350 punches/cm².

Equations (1) to (3), the coefficient determination (R^2) of Oil sorption, thickness, and Fabric density is 0.8782, 0.9165, and 0.8471, respectively. The result of R^2 indicates that the chosen factors for variation in oil sorption, thickness, and fabric density of needle punched nonwoven textiles can explain more than 87 % of the variability.

The signal to noise ratio is measured with enough precision, and values larger than 4 are preferred when choosing a model. In this study, the appropriate precision for oil sorption, thickness, and fabric density, respectively, is 10.072, 12.726, and 8.714 for all dependent variables. Table 5 shows the regression calculation of real components.

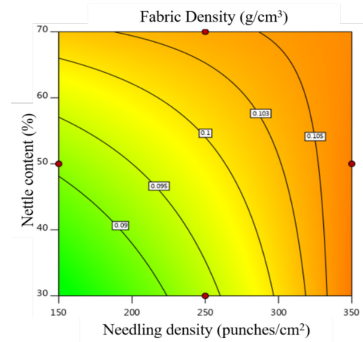

Figure 9: Impact of density of needle and amount of nettle on nonwoven textile density at 400 g/m² of textile weight

Table 4: "P" values for three dissimilar variables

Variables	*Oil sorption*	*Thickness*	*Fabric density*
Nonwoven Fabric weight (X_1)	0.0001	0.0075	0.0003
Needle Density (X_2)	0.1955	0.0005	0.2245
Blend Proportions (X_3)	0.0197	0.0002	0.0800

Table 5: Response surface equation and coefficient of multiple correlation

Response	*Surface equation*	*R^2*
Oil absorption %	$1692.466-369*X_1-76.375*X_2-157.125*X_3 59.75*X_1X_2+3.75*X_1X_3-25*X_2X_3-130.71X_1^2-61.96X_2^2+109.79X_3^2$ ------- (1)	0.8782
Fabric Thickness	$3.99+0.4250*X_1-0.3500*X_2-0.6000*X_3-0.0500*X_1X_2+0.0750*X_1X_3+0.1500*X_2X_3-0.842*X_1^2+0.1908*X_2^2-0.0842*X_3^2$ ------- (2)	0.9165
Fabric density	$0.0818+0.0205*X_1+0.0045*X_2+0.0068*X_3+0.0034*X_1X_2-0.0015*X_1X_3-0.0058*X_2X_3+0.0021*X_1^2-0.0072*X_2^2-0.0014*X_3^2$ ------- (3)	0.8471

Conclusion

Nonwoven textile weight, needle density, and combined proportions were used to investigate oil sorption, thickness, and fabric density of mechanical needle punched nonwoven textile. Nonwoven textile weight, needle density and blend proportions all substantially impacted oil sorption, thickness, and fabric density of nonwoven textiles. Oil absorption is higher in the 30% nettle, which has a lower needle density and fabric weight. The Nonwoven fabric thickness decreases in trend as the nettle content rises and the needle density increases. The fabric thickness decreases in trend With an increase in nettle and a greater degree of textile weight and needle density. With a lower fabric weight (200 g/m²), the fabric density rises as the nettle content rises. Even at lesser amount of nettle (30%) and maximum needle density ranges (290–350 punches/cm²), nonwoven textile density exhibits an increasing tendency as needle density increases. The nonwoven textile density may be increased by increasing the fabric weight (400 g /m^2), nettle content (70%), and needle density (350 punches/cm^2) levels.

References

Cheryan, M., & Rajagopalan, N. (1998). Membrane processing of oily streams. Wastewater treatment and waste reduction. Journal of membrane science, 151(1), 13-28.

Choi, H. M. (1996). Needlepunched cotton nonwovens and other natural fibers as oil cleanup sorbents. Journal of Environmental Science & Health Part A, 31(6), 1441-1457.

Debnath, S., & Madhusoothanan, M. (2010). Water absorbency of jute—polypropylene blended needle-punched nonwoven. Journal of Industrial Textiles, 39(3), 215-231.

Desai, A. N., Jade, B. D., & Balasubramanian, N. (1994). Tensile and absorbency characteristics of cellulosic nonwovens.

Diao, Z., Wang, L., Yu, P., Feng, H., Zhao, L., Zhou, W., & Fu, H. (2017). Super-stable non-woven fabric-based membrane as a high-efficiency oil/water separator in full pH range. RSC advances, 7(32), 19764-19770.

Lee, Y. H., Kim, J. S., Kim, D. H., Shin, M. S., Jung, Y. J., Lee, D. J., & Kim, H. D. (2013). Effect of blend ratio of PP/kapok blend nonwoven fabrics on oil sorption capacity. Environmental technology, 34(24), 3169-3175.

Lee, Y. H., Lee, E. J., Chang, G. S., Lee, D. J., Jung, Y. J., & Kim, H. D. (2014). Comparison of oil sorption capacity and biodegradability of PP, PP/kapok (10/90wt%) blend and commercial (T2COM) oil sorbent pads. Textile Coloration and Finishing, 26(3), 151-158.

Rengasamy, R. S., Das, D., & Karan, C. P. (2011). Study of oil sorption behavior of filled and structured fiber assemblies made from polypropylene, kapok and milkweed fibers. Journal of Hazardous Materials, 186(1), 526-532.

Renuka, S., Rengasamy, R. S., & Das, D. (2016). Studies on needle-punched natural and polypropylene fiber nonwovens as oil sorbents. Journal of Industrial Textiles, 46(4), 1121-1143.

Su, C. (2009). Highly hydrophobic and oleophilic foam for selective absorption. Applied Surface Science, 256(5), 1413-1418.

Vinitkumar, S., Parameswaran, S., & Kendall, R. J. (2017). Effect of micronaire on oil sorption capacity of three different types of greige cotton-based nonwoven substrate. Aatcc Journal Of Research, 4(2), 1-9.

Wang, Q., Cui, Z., Xiao, Y., & Chen, Q. (2007). Stable highly hydrophobic and oleophilic meshes for oil–water separation. Applied Surface Science, 253(23), 9054-9060.

Wei, Q. F., Mather, R. R., Fotheringham, A. F., & Yang, R. D. (2003). Evaluation of nonwoven polypropylene oil sorbents in marine oil-spill recovery. Marine Pollution Bulletin, 46(6), 780-783.