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Thermal Insulation Properties of KAPOK/Cotton Blended Non-Woven Fabric

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Abstract--- ***Kapok has excellent oil absorbency properties due to the hollow structure in the fibre. Kapok is widely used as stuffing materials and not used in apparels. The kapok and cotton blended nonwoven were made with 80:20, 70:30 and 60:40 proportions and three different thickness. The resultant kapok cotton blended nonwoven was subjected to thermal insulation, oil absorbency, and other physical properties. Lee's disc method has been used to test the thermal conductivity of the needle punched nonwoven fabric. The insulation property of the nonwoven fabric increases with increasing the thickness of nonwoven and number of layers. The insulating properties decrease with increase in the proportion of cotton.***

Keywords: Kapok, Cotton, nonwoven, thermal insulation, oil sorption capacity

INTRODUCTION

The thermal resistance of fabric depends upon the effective thermal conductivity and thickness. A change in thermal conductivity or thickness will have a big impact on the thermal resistance of the fabric. Traditional insulation materials such as mineral wool, cellulose, cork, and polyurethane are widely used because of their high thermal resistance[1].

Kapok is a silky cellulosic, single wall hollow unicellular natural fibre like cotton with a large lumen and thin cell wall[2]. It is seven times less dense than cotton and has buoyancy being able to carry up to twenty times its weight. Kapok fibre comprises 64% cellulose, 13% lignin, and 23% pentosan and it also contains waxy cutin on the fibre surface which makes them water repellent (hydrophobic), also they are oleophilic and biodegradable[3], [4]. Kapok fibre exhibits better performance in thermal properties compared to other natural fibres [5].

These fibres are used as stuffing for bedding, upholstery, life preservers and other water-safety equipment because of its excellent buoyancy, and for insulation against sound and heat because of its air-filled lumen. Due to its warmth retention properties, it can be blended with other fibre to achieve apparel textiles with desired characteristics. Recent applications of kapok fibres are as absorbent material for oils, metal ions, dyes, and sound. The special structure of kapok fibre would also be beneficial for the sound absorption[6].

In recent years, oil spill contamination has become one of the major problems of environmental pollution[7]. A hydrophobic-oleophilic surface is necessary for good oil sorbent. Oil sorbent surface with low surface energy can be easily wetted by oil[8]. To improve the oil sorption capability of sorbent, hydrophobic- oleophilic function groups can be introduced into the surface of materials, which will enable oil to adhere to the surface and increase the oil sorption properties[9]. The wax layer on its surface enables this fibre to show excellent hydrophobic-oleophilic characteristics, and accordingly, this fibre is receiving increasing interest as an oil-absorbing material [7].

In this research, the thermal insulation, oil absorbency and other physical properties of the Kapok / Cotton blended non-woven fabric of 80/20, 70/30, 60/40 with three different thickness was analysed.

Materials

In this research, the kapok and cotton fibres are used with the properties given in Table 1.

Table 1. Properties of Kapok and Cotton fibre

S.No	Properties	Kapok	Cotton
1	effective length	10 mm	25mm
2	density	1.31 g/cc	1.52 g/cc
3	Moisture content	14%	11.3%
4	Fineness	1.7micronaire	3.4micronaire
5	Wax content	8%	0.6%

Web Formation

The Kapok/Cotton nonwoven was made with three different ratios to analyse the effect of fibre proportion on thermal insulation. The Kapok and Cotton ratio of 80/20, 70/30 and 60/40 was used. Computerized miniature carding machine (shown in figure 1) was used for this purpose. Needle punched non-woven was produced on a needle loom.

Figure 1. Computerised carding machine

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The produced Kapok /Cotton nonwoven was subjected to different test methods. The fabric thickness tester was used to assess the thickness of the produced kapok cotton blended nonwoven. The thermal insulation properties of the nonwoven were assessed by ISO 5085 test methods using Lee's disc apparatus. The ASTM D 737 - 96. The test method was used to measure the air permeability of the sample it is and expressed in terms of cm3/s/cm2. The water vapour permeability index of the sample was calculated using the ASTM E 96 Water Method & Desiccant Method.

The dried fibre sample of 0.1 g immersed in oil for 15 minutes then the sample was taken out and drained and wiped with tissue papers and the oil sorption capacity was determined by calculating the difference in weightand calculated by the following formula.

$Q = (Wt - Wi - Ww) / Wi$

Where

Q is the oil sorption capacity of the sorbents calculated as grams of oil per gram of sample,

Wt is the weight of the wet sorbents after draining (grams),

Wi is the initial weight of sorbents (grams) and

Ww is the weight of water absorbed in the sorbents (grams).

In pure oil medium without any water, Ww is equal to zero.

Diesel oil, Machine oil, Sunfloweroil and Coconut oil were used for this purpose.

Result and Discussion

The thermal conductivity of single-layer Kapok /Cotton blended nonwoven is given in Table 2. It is clear that the increase in thickness, the thermal conductivity decreases from 0.0436 to 0.0246 Wm-1k-1when increasing the thickness from 1.5 mm to 3.00 mm. On the other hand, the thermal conductivity increase with an increase in the proportion of cotton. This indicates that the kapok fibre having good thermal resistance. The Table 3 and Table 4 shows the thermal conductivity of the two-layer sample and three-layer samples. This exhibits that the two-layer samples show good thermal insulation properties than the single layer fabric and the thickness decreases the insulation properties also decreases. This trend is followed in all the three combinations. A similar trend is also achieved in three-layer fabric also.

Table 2. The thermal conductivity of single-layer Kapok /Cotton blended nonwoven

Kapok / Cotton blend ratio	Thickness(mm)	Thermal conductivity value ($Wm^{-1}k^{-1}$)
80/20	3.00	0.0246
	2.00	0.0345
	1.50	0.0436
70/30	3.00	0.0284
	2.00	0.0406
	1.50	0.0497
60/40	3.00	0.0312
	2.00	0.0412
	1.50	0.0506

Table 3. The thermal conductivity of double layer Kapok /Cotton blended nonwoven

Kapok / Cotton blend ratio	Thickness(mm)	Thermal conductivity value ($Wm^{-1}k^{-1}$)
80/20	5.00	0.0046
	4.50	0.0057
	3.50	0.0073
70/30	5.00	0.0049
	4.50	0.0062
	3.50	0.0078
60/40	5.00	0.0054
	4.50	0.0071
	3.50	0.0087

Table 4. The thermal conductivity of three-layer Kapok /Cotton blended nonwoven

Kapok / Cotton blend ratio	Thickness(mm)	Thermal conductivity value ($Wm^{-1}k^{-1}$)
80/20	6.5	0.0002
70/30	6.5	0.0003
60/40	6.5	0.0005

Air Permeability

The air permeability of the kapok cotton blended nonwoven as shown in table 4. The air permeability of the sample varies with thickness and not affected by the variation in the proportionate of the kapok and cotton blend. This indicates that the air permeability is not affected by the type of fibre whereas, it is affected by the thickness of the sample.

Table 5. The air permeability of the kapok cotton blended nonwoven

Kapok/cotton blended ratio	**Thickness(mm)**	**Air permeability value ($cc/sec/cm^2$)**
80/20	3.00	440
	2.00	540
	1.50	720
70/30	3.00	450
	2.00	520
	1.50	690
60/40	3.00	455
	2.00	545
	1.50	710

Water Vapour Permeability

The Table 5. Shows the water vapour permeability of the Kapok/ Cotton blended nonwoven sample. The thickness of the nonwoven batt increases from 1.5 mm to 3.00 mm the water vapour transmission rate is also decreased and the same trend is followed in all the three ratios of the Kapok/Cotton blends. This indicates that the type of fibre has no influence on the water vapour transmission rate.

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Table 5. Water vapour permeability of the Kapok/ Cotton blended nonwoven sample

Kapok/cotton blended ratio	Thickness(mm)	Water vapour transmission rate (g/m^2/day)
80/20	3.00	735.85
	2.00	861.64
	1.50	883.65
70/30	3.00	792.45
	2.00	820.75
	1.50	842.77
60/40	3.00	1003.14
	2.00	1066.04
	1.50	1084.91

Oil Sorption Capacity

The oil sorption capacity of the kapok and cotton fibre was tested with different oils and the results displayed in Table 6. Kapok fibre shows good sorption capacity of all oils than comparing with cotton fibre. The sorption capacity of kapok is due to the large lumen in the centre and the waxy surface of the kapok facilitate to absorb the huge amount of oils.

Table 6. The oil sorption capacity of the kapok and cotton fibre

Types of oil	**Oil sorption capacity (g/g)**	
	Kapok	**Cotton**
Diesel oil	48.8	32.7
Sunflower oil	72.0	43.8
Coconut oil	90.9	48.3
Machine oil	122.3	63.2

CONCLUSIONS

The kapok/cotton blended nonwoven was produced with three different blend ratios 80:20, 70: 30, and 60:40 with three different thickness 3mm, 2 mm and 1.5 mm. the thermal conductivity of the sample was assessed for single layer, double layer, and triple layer. The single layer sample shows less thermal resistance than comparing with triple layer due to the entrapped air in between the layers and the thermal resistance increases with increase in thickness of the fabric. The air permeability and water permeability of the sample were also assessed and the air permeability and water vapour permeability is not influenced by the type of fibre. The oil sorption capacity of the kapok fibre is better than the cotton fibre. So kapok can be used as nonwoven along with cotton fibre, where the thermal insulation and oil sorption properties are necessary.

REFERENCES

1. P. Taylor, N. Ali, M. El-harbawi, A. A. Jabal, and C. Yin, "Characteristics and oil sorption effectiveness of kapok fibre , sugarcane bagasse and rice husks : oil removal suitability matrix," no. October 2014, pp. 37–41.
2. H. Xiang, D. Wang, H. Liu, N. Zhao, and J. Xu, "Investigation on sound absorption properties of kapok fibers," Chinese J. Polym. Sci., vol. 31, no. 3, pp. 521–529, 2013.
3. Y. Zheng, J. Wang, Y. Zhu, and A. Wang, "Research and application of kapok fiber as an absorbing material: A mini review," JES, pp. 1–12.
4. Y. Ding, Z. Cai, L. Wang, Y. Shen, and Q. Gao, "The Adsorption Character of Kapok Fiber and Reactive Dyeing Technology on Modified Kapok Fiber."
5. Udhaya M, Arun S Karthick, and Gobi N, "Development of Kapok / PP Blended Nonwovens for Thermal Insulation Application," 27th Natl. Conv. Text. Eng., vol. February, 2014.
6. Tatjana rijavec, "Kapok in Technical Textiles," Tekstilec, vol. 51, pp. 319–331, 2008.
7. J. Wang, Y. Zheng, and A. Wang, "Coated kapok fiber for removal of spilled oil," Mar. Pollut. Bull., vol. 69, no. 1–2, pp. 91–96, 2013.
8. X. Huang and T. Lim, "Performance and mechanism of a hydrophobic – oleophilic kapok filter for oil / water separation," vol. 190, pp. 295–307, 2006.
9. W. Sci, "Excellent oil absorbent kapok [Ceiba pentandra (L) Gaertn.] fiber : fiber structure, chemical characteristics, and application," pp. 401–404, 2000.

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