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Preparation of Nonwoven Fabrics using Natural Fibers by Needle Punching Technology

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ABSTRACT

The natural fibers like Banana, Coir, Cotton, Sisal and Jute have attracted the attention of scientists and technologist for application in consumer goods, low cost housing and other civil structures.

Nonwoven products are taking the place of many woven and knit materials because of their lower cost and lighter weight. Nonwoven fabrics are also predominate in the geotextiles industry because of their higher permeability, better friction and construction survivability compared to that of woven products point out Niir Board (2000). The fibres apart from low cost and renewable in nature, it is more attractive as reinforcing material for composite says Billie. J. Collien et al., (2001). The use of natural material gives the user or a designer more inspiration and indicates the flow and performance of a product.

A study was conducted in three districts of Southern part of Tamil Nadu namely Kanyakumari, Tirunelveli and Thoothukudi to find out the preference of nonwoven made up of natural fibres such as Jute, Coir, Banana and blends which were low cost and locally available fibers. Seven nonwoven samples were prepared by needle punching process from the selected natural fibers such as Jute, Coir, Banana as 1st, 2nd & 3rd samples Coir and Jute, Coir and Banana, Banana Jute as 4th, 5th, 6th samples and Jute Coir Banana as 7th sample. The study revealed that the country fishermen and company owners were concerned with marine environment and they preferred to select nonwoven made of natural fibres at affordable cost.

Keywords: *Nonwoven, Natural Fibres-Jute, Coir, Banana, Needle Punching*

INTRODUCTION

Ward (1997) states that nonwoven as structure consists of a web of fibers joined by chemical or mechanical means. Nonwoven is usually made by producing a web of fibers, which is then strengthened by various bounding techniques. More recently needling has been used in the production of higher performance fabrics. There have been developments in the speed of the needle punching machines. Taking punching speeds to 900 strokes per minutes and increasing needle densities. Special advantages have been claimed for the new process developed by manufacturing companies in which the web is needled from both sides by inclined needle. This process and others have been successful in the production of good quality nonwoven mats.

Bio based nonwoven geotextiles made from bast fibers like hemp, flax, jute, kenal and bagasse could be used for temporary applications where bio degradability is required such as erosion control. There are many other nonwoven materials that utilize natural fibers especially for floor coverings, building materials and particle boards.

The importance of Jute fibre was revived by the consumer world over the years focusing on eco-friendly materials from sustainable resources. Jute fibre has made a niche for itself in the field of technical textiles by serving as a substitute for plastics, wood and asbestos. The various Jute based products are being used for agricultural, automobiles, architectural, geotechnical, protective and decorative purposes points out Cowking et al (1994). Although Jute fibre could never be thought for apparel use they have the following exclusive properties like high strength, high abrasion resistance, reasonable resistant to heat and does not melt, durable, washable when combined with synthetic fibres and chemically treated. They are low cost, bio degradable and environmentally friendly say Shrikanth Rao (1995).

According to Mathai (1998), Coir is one of the industrial hard fibers enjoys a unique position. Among all the natural fibers, Coir has the highest tensile strength and it retains much of the tensile strength under wet conditions. Coir fibre is well known for its stiffness and resilience. It can withstand large amount of pressure and abrasion. Coir gives a variety of eco-friendly products suitable for industrial and domestic uses. Coir fibre plays a a major role in geotechnical engineering which includes earth structures, roads, dams, canals, rivers fumigations etc. The Coir fibre can be used for thermal insulation due to its good insulation property.

Banana fibre is a natural fibre with high strength and can be blended easily with cotton or other synthetic fibres to produce blended textiles. The Banana plant has long been a source of fibre for higher quality. 100% eco-friendly and possess excellent natural alternative to replace plastic paper. They are environmental friendly at every level.

The natural fibers have started to be used again because of being naturally derived from plants and due to their characteristics of being light weight compared to glass. The plant fibre reinforcements are resoluble, good insulator of heat and sound, degradable and have a low cost. Natural fibre can be substituted for glass and carbon.

Fibre glass is most flexible than wood, carbon and kevlar and is close to wood regarding mechanical properties. The need for using natural fibres such as jute, banana and coir in the place of the traditional glass fibre partly or fully as reinforcing agents as composites is emphasized.

Methodology

Natural fibre apart from low cost eco-friendly and renewable in nature, it is more attractive as nonwoven and as a reinforcing material in composites says Billie. J. Collien et al. (2001). Viriginia Henckon (2005) views that since the last decade, a great deal of emphasis has been focused on the development and application of natural fibre nonwoven reinforced composite materials in many industries. The demands of these industries are weight retention and fuel economy and several automobiles have been constructed using natural fibre nonwoven with epoxy resins. Hence the investigator selected the natural fibres such as Jute, Coir and Banana to prepare nonwoven. The properties of the selected natural fibres are given in Table - I.

Table – I - Properties of Jute, Coir and Banana

Name of the fibres	Length (cm) Range	UTS / Mpa	Elongation (%)	E(GPa)	Modules of Elasticity ($MN.m^{-2}$)	Regain (%)	Tenacity (g/d tex)
Jute	150-360	200-800	1.16-8	10-55	533	12	3.1
Coir	50-150	106-175	14.21-49	4-6	131-175	10	1.8
Banana	80-280	529-914	3	27-32	529-754	15.2	1.7-7.9

Locally available and low cost fibres like jute, coir and banana were selected. The selected natural fibres such as jute, coir and banana were mixed to produce the various samples such as 100 % jute, 100 % coir, 100 % banana, as sample one, two and three; 50 % jute and 50 % coir as sample four; 50 % coir and 50 % banana as sample five, 50 % of jute and 50 % of banana as sample six, and a mixture of jute, coir and banana (33:33:33) as sample seven were prepared. Altogether seven nonwoven samples were prepared from the selected natural fibres.

Production of Nonwovens

The study revealed that the selected fibres such as jute, coir and banana were sorted out separately. Preliminary washing treatment was given to remove the impurities like dirt, stone, sand etc., and kept separately. Softening is the process of spraying "Emulsion" (a mixture of water, mineral oil and detergents) in a predetermined proportion to the fibres and keeping them in bins for a period of time points out Booth (2000).

All the selected fibres were subjected to scouring treatment and each fibre was treated separately with the help of the softener (turbo softness) and it was kept for 12 hours to soften the fibre which would make it easier for cutting.

The punched density used was 240 needles per square meter and ½ inch penetrate. Barbed needle type was used with 75 punch / square centimeter. Foster 15 X 18 X 36 X 3 rb X F20-9-4NK. The cut fibres were weighed separately and fed into the finisher card with cross lapper. In the finisher card the required GSM was obtained by adjusting the cross lapper feed. The selected fibres were fed into the breaker card to form uniform silver. Mixing of fibres was done as 100:100, 50:50 and 33:33:33. In the finisher card, the work of weight reduction was done by drafting, and weight leveling by doubling and mixing of various types of fibres.

Production of Needle Punched Nonwoven Fabrics

The machine called OSKAR DILO Maschinen Fabric KG, Edenbergh was used to prepare the nonwoven. The fibre mixtures with different variations were fed into the Dilo Machine to prepare needle punched nonwoven.

The capacity of the machine was characterized by over 30,000 needles per metre of working width stoke frequencies executing 2000 min^{-1} and production speeds of up to 15/min. The speed of the machine was regulated by the operator. The speed of the machine frequencies was 120 strokes per minute, the infeed was 0.25 meters per minute, and draw up speed was 0.23 meters per unit.

Formation of Mat

The fibre was converted to a mat with the help of the needle punching process to form a continuous sheet of chopped strand of mat with variable thickness. The material was specified by weight 270 : 310 : 320 : 380 : 400 : 450 : 510 GSM and in rolls of 15 to 20 kg were taken which were about 70 cm in width is given in the Table – II.

Table – II - GSM of the Prepared nonwoven

Sl.No	Name of the nonwoven	GSM
1.	Jute	270
2.	Banana	320
3.	Coir	510
4.	Jute Banana (JB) (50:50)	380
5.	Jute Coir (JC) (50:50)	450
6.	Banana Coir (BC) (50:50)	400
7.	Jute Banana Coir (JBC) (33:33:33)	310

The investigator carried out few tests to find out the properties of the prepared nonwoven like visual inspection, fabric thickness, abrasion resistance, tensile test and the opinion of company owners on physical properties which are given in Result and Discussion.

Result and Discussion

The Opinion of company owners on the physical properties of the prepared nonwoven

The nature of the fibre preferred by the company owners to prepare the nonwoven is presented in Table – III.

Table III - Fibre Materials Preferred by the Company Owners to Prepare the Nonwoven

Sl.No	Materials Preferred	Percentage
1.	Nonwoven from plant fibre	46
2.	Nonwoven from mineral fibre	05
3.	Nonwoven from polyester	18
4.	Nonwoven from nylon	12
5.	Plywood	19

Hence it was concluded that since more than forty five percent of the company owners preferred nonwoven made of natural (plant) fibres, the investigator selected plant fibres such as coir, banana and jute due to their availability in the field of study.

Properties Preferred by the Company Owners among the prepared Nonwoven

The properties preferred by the company owners among the prepared nonwovens are given in Table – IV.

Table IV - Properties Preferred by the Company Owners among the prepared Nonwovens

Sl.No	Properties Preferred by the Company Owners	No.of Individual Stating
1.	Durability	95
2.	Floating	67
3.	Less maintenance	91
4.	GSM selected 250-350	78
5.	Eco-friendly	84

Hence it was concluded that most of the company owners preferred that the prepared nonwovens ought to have durability, easy to maintain, eco-friendly, to have the GSM between 250-350 and should have floating capacity.

Physical Properties of Nonwoven

Visual Inspection

The visual inspection was carried out with the help of 25 college students for the nonwovens selected are tabulated in Table V. It was felt that the general appearance of the banana nonwoven was good stated by 20 students and 14 students expressed that the jute coir was fair than the other nonwoven samples. Few of them stated that coir had poor appearance. Seventeen students felt that the lustre of the banana were good when compared with other samples. Few of them felt that (JB) jute banana had medium lustre and 10 of them stated that coir had low lustre.

Table V - Visual Inspection of Nonwoven

Name of the selected Nonwoven	General Appearance			Lustre			Colour			Texture		
	Good	Fair	Poor	High	Medium	Low	Dark	Light	Dull	Fine	Rough	Smooth
Jute	15	10	-	10	9	6	-	4	21	-	19	6
Coir	14	10	5	6	9	10	18	4	3	-	25	-
Banana	20	5	-	17		3	-	22	3	-	23	2
Jute Coir	7	14	4	9	12	4	10	10	5	-	25	-
Coir Banana	10	9	6	10	8	7	10	9	6	-	22	3
Jute Banana	14	8	3	15	10	-	7	18	-	6	19	-
Jute Coir Banana	14	11	-	14	9	2	4	16	5	5	20	-

Hence it was concluded that the banana nonwoven sample was good in appearance and texture of coir was dark in colour whereas banana and jute banana were light in colour and the texture of all the selected nonwovens were rough.

Table VI - Thickness of the prepared Nonwoven

Name of the Selected Nonwoven	Size of the Material (cm)	Thickness of the Material (mm)
Jute	5 x 5	3.4
Coir	5 x 5	8.22
Banana	5 x 5	4.79
Jute Coir (50:50)	5 x 5	5.43
Coir Banana (50:50)	5 x 5	6.22
Jute Banana (50:50)	5 x 5	4.59
Jute Coir Banana (33:33:33)	5 x 5	3.94

From the Table - VI, it was observed that coir nonwoven had highest thickness and the lowest was found in jute nonwoven.

Abrasion Resistance

A study was carried out to find out the abrasion resistance of the prepared nonwovens in saline water. The following table VII indicates the abrasion resistance of the nonwoven before and after treatment with saline water.

Table VII - Abrasion Resistance of prepared Nonwoven

Name of the Nonwoven	Elongation	
	Before	After
Jute	5000 Rubs 3.5 (HDP)	3 (HDP)
Coir	5000 Rubs 4 (HDP)	3.5 (HDP)
Banana	5000 Rubs 3.5 (HDP)	3.5 (HDP)
Jute Coir (50:50)	5000 Rubs 3 (HDP)	3 (HDP)
Coir Banana (50:50)	5000 Rubs 4 (HDP)	3 (HDP)
Jute Banana (50:50)	5000 Rubs 3.5 (HDP)	3 (HDP)
Jute Coir Banana (33:33:33)	5000 Rubs 3.5 (HDP)	3 (HDP)

The study revealed that when it was exposed to 5000 rubs in the selected nonwoven samples before treating with saline water, the coir had highest rubs also Banana Coir and Jute Coir Banana.

Hence it was concluded that rubs were absorbed more higher in nonwoven before treating with saline than after treatment. Medium rubs was observed in Jute Banana and Banana whereas Coir Jute has the lowest rubs.

A study also revealed that when 5000 rubs were given to the selected nonwoven after treating with saline water. Coir Banana had under gone more rubs whereas Jute, Jute Coir, Jute Banana, Jute, Banana Coir and Jute Banana Coir had the same rubs.

Hence it was concluded that rubs were absorbed more higher in nonwoven before treating with saline water than after treatment.

Tensile Strength

The tensile properties of the prepared nonwoven tested in machine and cross wise direction are given in Table VIII and Table IX.

Table VIII - Tensile Strength of the Nonwovens Tested in Machine Wise Direction

Type	Tensile Strength in Machine Direction (KN/m^2)			Tensile Elongation in Machine Direction (%)			Initial Modulus (KN/m^2)
	Range	Median	Variance	Range	Median	Variance	
Jute	16.57	15.38	2.39	24 to 30	26.75	4.55	49
Coir	12.27 to 13.18	12.73	0.17	17 to 19.15	18.15	0.70	42
Banana	11.48	7.62	2.26	11.25 to 16.67	12.08	6.89	68
Jute Coir	9.79 to 13.75	11.45	3.11	20 to 26.67	25.42	9.90	46
Jute Banana	5.85 to 7.84	6.34	0.61	17.5 to 26.67	20	6.17	48
Banana Coir	3.64 to 4.09	3.86	0.03	17.5 to 23.5	19.64	1.29	30
Jute Banana Coir	5.83 to 8.92	7.50	0.91	20 to 28.25	26.25	12.96	45

From the study it was observed that the tensile strength in machine wise direction is higher for jute compared to other nonwovens. Among the blended nonwovens, it can be clearly seen that the presence of jute had significant impact in the improvement of the tensile properties of the nonwovens. It was also noted that the initial resistance to deformation (modulus) is higher in the nonwovens made from banana fibres. The coefficient of variation in the tensile strength of nonwovens indicates, a fair level of uniformity in the specimens.

Hence it was concluded the tensile strength of jute nonwoven in the machine wise direction was found to have higher when compared to other nonwovens. The presence of jute has significant impact in the improvement of the tensile properties of the nonwovens.

Table IX - Tensile Properties of the Nonwovens Tested in Cross Wise Direction

Type	Tensile Strength in Machine Direction (KN/m^2)			Tensile Elongation in Machine Direction (%)			Initial Modulus (KN/m^2)
	Range	Median	Variance	Range	Median	Variance	
Jute	7.46 to 9.36	8.25	0.54	24 to 31.5	26.5	11.83	25
Coir	2.24 to 3.13	2.76	0.20	37.50 to 32.50	31.67	7.18	16
Banana	1.70 to 3.31	2.96	0.58	7.08 to 16.67	9.67	13.39	20
Jute Coir	1.70 to 3.31	2.96	0.58	7.08 to 16.67	9.67	13.39	12
Jute Banana	1.50 to 1.87	1.70	0.02	29.17 to 35	35	10.198	10
Banana Coir	0.65 to 0.99	0.84	0.02	22.08 to 25	22.5	12.99	9
Jute Banana Coir	0.52 to 0.67	0.65	0.004	10.83 to 19.17	16.67	11.61	10

From Table IX it was found that there is significant drop in tensile properties when tested in cross wise direction compared to machine wise direction. This is due to the poor contribution of the fibres to the load in this direction. Jute fibre showed the better tensile strength compared to those of the other fibre based nonwovens. Moreover the modulus is higher for jute based nonwovens indicating high resistance to deformation values of the elongations (%) of the nonwovens. However, do not have a predictable trend which is due to the high variance in elongation values. The elongation percentage is slightly higher in machine wise direction compared to cross wise direction.

From the study it was concluded that there is significant drop in tensile properties when tested in cross wise direction compared to machine wise direction. The elongation percentage is slightly higher in machine wise direction compared to cross wise direction.

Table – X - Data on density and void content of composites

Fibre	% Void Content	Density (g / cc)
Jute	1.43	1.3
Coir	1.3	1.35
Banana	1.14	1.45
Jute Coir	1.21	1.15
Jute Banana	1.31	1.52
Banana Coir	1.22	1.29
Jute Banana Coir	0.89	1.23

From the table X it was concluded that the void content of jute and the density of jute banana was higher when compared to other nonwovens.

CONCLUSION

The study revealed that the company owners preferred the nonwoven materials made up of natural fibres than the traditional wood, glass and synthetics. The study also stated that the company owners choose nonwoven for construction of country boat as they are

durable and has the floating capacity. The GSM of the nonwoven suggested was between 250 - 350 and should be less cost and eco-friendly.

From the result it was observed that jute nonwoven exhibits the maximum strength in comparison with coir and banana nonwoven. Tensile strength of jute nonwoven fabric was found to be maximum but the effect of water treatment has lowered the strength. The banana coir blend showed the least strength. Machine wise tensile properties were found to be higher than those of cross wise direction. Tensile elongation was generally found to be higher in machine direction. Initial modules of the nonwoven fabrics were found to be higher in machine direction.

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