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Development of sunnhemp (*Crotalaria juncea)* fibre based unconventional fabric

Surajit Sengupta*, Sanjoy Debnath

ICAR-National Institute of Research on Jute and Allied Fibre Technology, 12, Regent Park, Kolkata 700 040, India

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ABSTRACT

Sunnhemp fibre is an under-exploited natural fibre. In this study, an attempt has been made to explore the possibility of production of unspinnable sunnhemp based unconventional fabric (needle punched nonwoven) for value addition and diversified uses. Mechanical processing for preparation of all sunnhemp, sunnhemp-jute (1:1) and sunnhemp-polypropylene (1:1) blended needle punched nonwoven has been optimised and processing parameters have been suggested. Softening treatment of sunnhemp fibre has been done successfully for better processing. Boiling in water with 1% nonionic detergent for 15 min has been suggested as pre-processing for softening. Tenacity, elongation-at-break, initial modulus, breaking energy, stress relaxation, creep, compressibility, recovery-from-compression, bending load, electrical insulation, thermal insulation, sound insulation, air permeability and frictional force have been evaluated and analysed for all the above-mentioned samples. Based on those properties the probable use has been suggested.

1. Introduction

Conventional fabric preparation consists of about ten steps of sequential processing of fibres commonly known as spinning (making thread) and weaving/knitting (making fabric). An unconventional fabric, called nonwoven, is a textile structure produced by the bonding or interlocking of fibres, or both, accomplished by mechanical, chemical, thermal or solvent means and combinations thereof. In one system, a fibre web i.e. a thin layer of fibres is prepared in which fibres are attached by surface cohesion only and then the layer is laid many folds (several webs on top of each other called cross laying) to form a butt, which goes directly to bonding by mechanical means using barbed needles. This is called mechanically bonded fibre sheet or more technically needle punched nonwoven. Needle punched nonwoven is bulky, uniform and possesses excellent hydraulic and thermal insulation property with lower but sufficient strength (Mao et al., 2007; Lunenschloss and Albrecht, 1985) Fig. 1.

Sunnhemp (*Crotalaria juncea* L.), a natural cellulosic bast fibre, is obtained from a plant which is grown in India and neighbouring countries like China, Korea, Pakistan, Bangladesh, Romania, Russia. (FAO, 2014). These countries cover nearly 320 thousand hectares producing approximately 200 thousand metric tons of fibre. (Chaudhury et al., 2016). This crop is mainly grown for green manure, fodder and to some extent for fibre to make ropes. It is coarse, strong, brown-yellow coloured fibre. In terms of fineness, the sunnhemp fibre is finer to jute, sisal, mesta, and coir, but less fine than cotton and flax. But in terms of tenacity, a measure of strength, sunnhemp fibres are considered superior to jute and mesta, but less stronger than flax, sisal, and manila hemp. The major constituents of sunnhemp fibres are cellulose and pentosan (Joshi, 2015). Harvesting of the plant at early pod stage is very important for ensuring the better quality of fibre. However, the practice of harvesting at dead ripe pod stage is done in view of the seed yield, in addition, deteriorating the quality of fibre. It is extracted from the plant after retting which is done in water at about 30 °C in 7–8 days. Kundu (1964) reports that the actual proportion of bast fibre in dry stalks ranges from 6.4% to 10.5%. (Kundu, 1964). This fibre has enough possibility to use in value-added diversified areas. Hence, it can be denoted as under exploited fibre Fig 3.

In this study, an attempt has been made to explore the possibility of production of unspinnable sunnhemp based needle punched nonwoven. Its properties have been evaluated and based on those properties the probable use has been suggested.

2. Experimental

Sunnhemp fibre has been collected from Sunnhemp Research Station, Pratapgarh, Uttar Pradesh, India. This fibre has been harvested from the plant at dead ripe pod stage for seed yield. Therefore, this is a by-product of the plant because its fibre like properties is poor. The essential fibre properties have been evaluated from the carded sliver

* Corresponding author.
E-mail address: surajit.sengupta@icar.gov.in (S. Sengupta).

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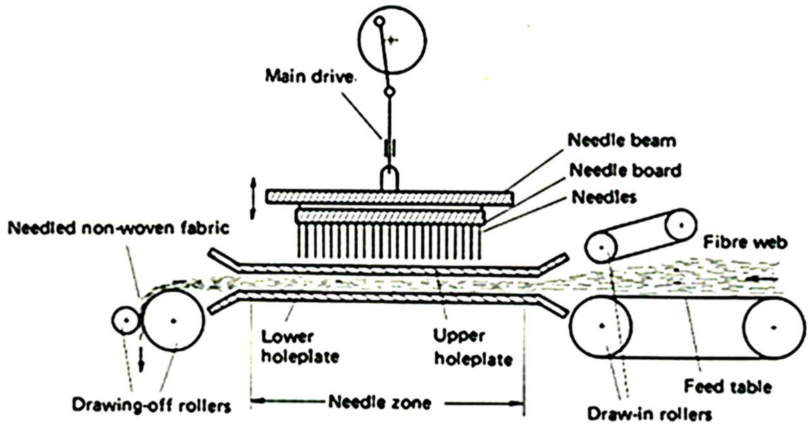

Fig. 1. Schematic diagram of needle loom copy.

using the following procedure.

Untreated fibres from the carded sliver have been sorted in five different length group. Twenty fibres from each length group have been collected randomly and tested for length (using a scale), fineness (weight by digital microbalance and then converted to tex using length data) and tensile property (using Instron strength tester by paper box method). Flexural modulus has been tested by loop deformation method. Swelling has been measured using a microscope. Moisture content has been calculated by comparing the bunch of sample in standard atmosphere with oven dry condition. Table 1 shows the properties of the collected sunnhemp fibre.

2.1. Treatment of fibre

As the fibres are coarse with low extensibility, it is rigid in nature. Batching oil and water emulsion spray and subsequently processed in softener, as used in jute, may be also adopted for sunnhemp softening. But it is felt that this is not enough for smooth processing. Hence, some mild treatment, as mentioned below, has been tried.

Treatment 1 Boiled in water for 15 mins,

Treatment 2 Boiled in water with 1% nonionic detergent for 15 mins,

Treatment 3 Treated with 1% NaOH Soln for 15 mins,

Treatment 4 Treated with 1% HCl solution for 15 mins

Treatment 5 Treated with 0.5% Silicone softener for 15 mins

All the treated fibres have been processed separately up to finisher card following the standard procedure. The fibre test has been carried out from finisher card sliver and reported in Table 2.

Table 2 shows the lowest rigidity in treatment 2, fibre strength and elongation reduction in treatment 3 & 4, very low coefficient of friction in treatment 5. It is also found that there is almost no change in properties in boiling only (treatment 1). Therefore, treatment 2 has been selected for further study due to better length distribution, finer fibre distribution, higher strength, higher elongation, suitable frictional property and moisture content in addition to lower rigidity. This treatment cleans the fibre surface in presence of detergent in hot condition resulting in improvement in marginal improvement in properties. Treatment 3 & 4 not only reduces the strength but also removal of acid or alkali is a difficult task to be performed before processing. Treatment with silicone softener (treatment 5) reduces the fibre to fibre friction and hence, difficult in processing. The subject assessment by hand feel also gives the same inference. From Tables 1 and 2, it is found that treatment of sunnhemp fibre with 1% nonionic detergent under boil increases mean length by 13 mm, decreases mean fineness by 0.6 tex and flexural modulus by 36 dyn/cm^2.

Table 1
Properties of untreated sunnhemp fibre.

		CV%
Avg. Length (cm)	38	21.23
Max. Length (cm)	98	–
Min. Length (cm)	4	–
Avg. Gravimetric fineness (tex)	9.2	17.52
Max. fineness (tex)	14.1	–
Min. fineness (tex)	6.9	–
Avg. Tenacity (g/tex)	26.5	18.15
Max. Tenacity (g/tex)	30.3	–
Min. Tenacity (g/tex)	23.2	–
Breaking extension (%)	3.1	–
Flexural modulus (dynes/cm^2)	125	–
Transverse swelling in water (%)	17.6	–
Moisture content, %	8.4	–

2.2. Process optimization

Sunnhemp reeds are sprayed with castor oil emulsified in water. The wet fibres are kept in a closed container (bin) for better and uniform absorption of oil emulsion. Then removing from the bin, it is processed in the jute breaker card and finisher card to individualise the fibres. These fibres are fed to the conveyor of carding machine of nonwoven preparation and finally, a pre-needled fabric has been made. This pre-needled fabric is stacked in layers followed by needling by 25 gauge needles to get required g/m^2 fabric. In this process, following parameters have been optimised individually based on ease in processability, waste generated and final quality in terms of irregularity Fig. 2, Fig. 3a, Fig. 3b, Fig. 4, Table 3, Table 4.

2.3. Construction details of samples

Details of samples have been shown in Table 5.

2.4. Measurement of compressional behaviour

The compression and recovery between 0 and 200 kPa were measured in Instron Tensile Tester (Model No. 5567). The gauge length between a stationary anvil and pressure foot was set in 0 mm. The needle-punched nonwoven sample was placed between 150 mm diameter stationary anvil and 150 mm diameter pressure foot, which are well separated at the start of the experiment. Then the pressure foot started moving downward at the speed of 2 mm per min. After reaching the maximum compressional load of 3532 N (exerts a pressure of about 200 kPa), the pressure foot automatically started to move up in the same speed i.e. 2 mm/min decreasing the load accordingly. A diagram, plotting the compressional load against thickness, Fig. 5 was available along with a report of compressional deformation in required compressional load. Average of ten such diagrams was considered here.