Studies On Pine Needle (Leaves) Fibre : Pinus Roxburghii

J.S. Chawla
Regional Research Laboratory, Jammu-Tawi-180001

The paper reports the investigation on the fibre of Pinus roxburghii needles (leaves). There is a huge quantity of fall of these leaves in pine forests every year which dry up and pore a fire hazard to the forests. Process and technology for using the needles for fibre board was developed by the author. Pine needle fibre board possessed modulus of rupture in the range of 240-345 kg/cm² at a density of 1.0 g/cm³. Pine needle fibre board was used for making fruit packing cases. Pulping studies of the needles by sulphate method gave poor pulp yields (29.5%). The average fibre length and fibre width of the sulphate pulp fibre was 922 microns and 16 microns respectively. Pine wool the long fibre of pine needles were isolated by chemi-mechanical methods. The fibres were studied for fineness tensils strength and extension and compared with coir and sisal fibres. The pine needle fibres were examined by scanning, Electron Microscope and were compared with Scots pine needles (P. sylvestris).

Pinus roxburghii

(P. longifolia) is a tall tree of coniferous species with spreading crown. It is a gregarious tree forming pure forests over the sub-Himalayan belt from Kashmir to Bhutan at an altitude of 500 m. to 1500 m. under sub-tropical climatic conditions. The absolute maximum shade temperature varies from 32°C to 38°C. These pine forests receive the bulk of the rain fall during the monsoon. The leaves of the tree are in clusters of three which are needle like. There is a huge fall of pine needles (leaves) in the month of April to June. Those who have a chance to pass through the pine forests would notice an enormous amount of dry brown fallen needles under forest canopy lying on the ground in thick layers. It is estimated the fall of needles is about one tonne per hectare per season. About 4.0 to 5.0 kg leaves are shed by one tree of matured growth. Some foresters say the fall of these needles is about 3 tonnes per hectare per season, depending upon the density of the forest.

The pine needles are a fire hazard to the forest and an irritant to the villagers as these do not allow the grass to grow underneath for the cattle. The area under pine forest in 3 Himalaya States alone is about 7,00,000 hectares. The pine needles have not been utilised far for any industrial purpose. The utilisation of pine needles for the production of fibre boards was established by the author particularly for making packing boxes. The fibre boards could be used for making packing case of 18" × 12" × 12" size for the transportation of fruits especially apples. The fibre board with density 1.0 g/cm³ possesses modulus of rupture and tensile strength in the range of 290-345 kg/cm² and 150-175 kg/cm² respectively. Fibre boards as thick as 10 mm were made. Fortunately in India the zone of pine is closer to the apple orchards. Both are found in mountain areas of Himalayan, it was suggested by the author that the small scale unit on fibre board of 2 to 5 tonne/day capacity may be set at different places near pine rich areas, so that the needles are collected and processes near the site of the raw materials. A 2 tonne small scale plant was set up by a Forest Corporation of one of the Himalayan States in India for fruit packing cases based on the know-how provided by the author. Another product to which the pine needles could be used is for the production of pine wool. A complete process for large scale processing too was developed in this laboratory. Isolation of fibres from the needles was done by chemi-mechanical method. The wool could be used as a material for mattresses, furniture, as a cushioning material for packing of fragile articles, etc. It has a great scope to find sophisticated and uses such as rubberised fibre and as thermal insulation material. The physical chemical characteristics of the pine needles are given in Table I. Chemical analysis was carried out by Tappi methods.

TABLE 1

Physico-chemical Characteristic of Pine Needle

Physical characteristics	
1. Colour when dry	= light brown
2. Length of the needle	= 15 to 20 cm
3. Diameter	= 0.5 to 1.00 mm
4. Bulk density	= 0.05 g/cm³
Chemical characteristic	
1. Extractives	
a. Ether	= 4.47 percent (Oven dry basis)
b. Alcohol benzene 1:2 by volume	= 4.81
c. Hot water	= 17.6
2. Pentosan	= 13.3
3.*Lignin	= 31.0
4.*Holo-cellulose	= 70.5
5.*Alpha cellulose	= 42.8
6. Ash	= 2.44
7. Hydrochloric acid insoluble	= 0.16%

* Calculated on extractive from oven dry basis.

Pulping of the pine needles was carried out by sulphate method using total chemical 25% ($NaOH+Na_2S$). The condition of pulp preparation and the characteristics of the pulp are given below (table 3).

TABLE—3

1. Total chemicals	= 25.0%
2. Sulphidity	= 25.0%
3. Solid : Liquid	= 1:7
4. Temperature of pulping	= 170°C
5. Time of pulping at 170°C	= 4.0 hours excluding 1 hr to reach the maximum temperature.

Characteristics of sulphate pulp

1. Yield of unbleached pulp	= 29.5%
2. $KMnO_4No$	= 18.5%
3. Lignin	= 12.0%
4. Holo cellulose	= 88.1%
5. Alpha cellulose	= 77.0%
6. Pentosan	= 7.16%

TABLE 2

Results of Strength Properties of Pine Needle Fibre Boards made in the Laboratory

	Additional treatment	*Density g/cm³*	*Modulus of rupture kg/cm²*	*Tensile strength kg/cm²*	*Water absorption under water immersion*	
					2 hrs %	*24 hrs.* %
1.	Nil	0.97	290	167	23.4	86.0
2.	Nil	1.00	345	165	54.0	—
3.	Wax coated both sides	1.10	335	160	4.2	39.6

TABLE 4

Fibre Dimension of the Sulphate Pulp Fibre

1. Average fibre length	= 922 microns
2. Range of fibre length	= 315 to 1755 microns
3. Average fibre diameter	= 16
4. Range of fibre diameter	= 7 to 26
5. Ratio of fibre diameter to length	= 1:57.6

TABLE 5

Fibre Classification of Pine Needle Sulphate Pulp Fibre Length

Length

Range microns	*Percentage number*
300-500	12.0
501-700	26
701-900	12
901-1100	12
1101-1300	12
1301-1500	6
1500-	10
	100

Width

7-10	18
11-16	50
17-23	25
24-	7
	100

The pulping date shows that the yield of the unbleached pulp is very poor. It is only 29.50% by sulphate method of pulping having $KmnO_4$ No. 18.5 as compared to that of hard woods which is as high as 50% and the delignification could be achieved only upto 12.0%. The fibres are cylindrical and uniform. The average fibre length and diameter of 100 fibres in 922 microns and 16 microns respectively (Table 4). The fibre classification is given in Table 5.

Straw boards were prepared from pine needles by lime cooking (Guha et al). The needles were cooked with lime. The quantity of lime used as CaO varied from 8-16% on the weight of the needles and that of cooking temperature from 135°C to 162°C for a period of 4 hours. Pulp yield for straw board was in the range of 41 to 63.3%. Pine needles gave poor yields and poor strength compared to that of wheat straw.

Pine wool

The method for the preparation of pine wool consists in giving a softening treatment with mild alkali solution at 130-140°C under pressure for 3-4 hours followed by mechanical separation of fibres in suitable machines. The coarse fibres after centrifuging and sun drying were then processed in a machine to get uniform wool like material. The yield of the finished wool is 70-75 based on the dry weight of the raw needles.

A small sample of the pine wool was taken for the examination of fineness, tensile strength and extension characteristics. These tests were carried out in the Fibre Division of Tropical Products Institute, London. The sample of the pine wool had fibres of varying dimensions. 25 samples of almost the size of whole pine needles and 25 of the very finest fibres that were long enough for the test, were picked out at random. The two groups were tested separately.

Testing

The middle 2.5 cms of such fibre was cut out and conditioned at 68°F±2°F and RH 65%±2%. The conditioned fibres were weighed to determine fineness. These fibres were then commented on the strips of thin card board across circular holes 1 cm in diameter. The card sheet was then given from one side of the hole to expose the fibre free for tensile strength. They were tested on the Instron tensile testing machine using a guage length of 10 mm and a constant rate of expendion of 0.25 cm/min.

Results

The fibre fineness is expressed in Tex (i.e. the weight in grams of one kilometer of fibre).

Coir

A small sample of bleached coir fibres (25) were tested at TPI in a way similar to that in which the pine needle fibres were tested. The results are as follows:

TABLE 7

Average fineness	=	88.32 Tex
Average breaking load	=	1121.2 g
Tensile strength	=	12.7 g/Tex
Percentage extension	=	33.9

The above figures for tensile strength and extension are similar to those quoted in "COIR", Council of Scientific and Industrial Research, New Delhi, 1960, which are as follows:

Tensile strength	=	12.0g /Tex
Percentage extension	=	29.04

The figures quoted in "COIR" are based on tests on 1200 fibres for tensile strength and 1194 fibres for extension of grade FFF coir. However, the method of test used is not described.

TABLE 6

Physical Properties of Pine Wool Fibres

	Coarse	*Fine*
1. Average fineness tex.	114.4	9.6
2. Average breaking load g	480.0	79.4
3. Tensile strength g/tex	4.20	8.20
4. Percentage extension	5.6	8.9

Sisal

Samples of different cuts of hybrid sisal from Kenya (H 1300) were tested at TPI in a similar way to that in which the pine needle fibres were tested. The results are as follows:

TABLE 8

Cut	*No. of fibres tested*	*Average fineness (tex)*	*Average breaking load(g)*	*Tensile strength (g/Tex)*	*Extension %*
1st	228	15.1	886	58.8	4.2
3rd	254	24.4	1358	55.7	4.7
5th	195	19.5	835	42.7	5.0

The Characteristics of the processed fibres of pine wool obtained from pine needles when compared to other material is as given in Table 8.

TABLE 9

Material	*Bulk density g/cm³*	*Density of packing g/cm³*	*Sound absorption coefficient at a fregnouring of 512 cycles/sem*
1. Cotton	0.032	0.096	—
2. Pine wool	0.036	0.073	0.18 ($\frac{1}{2}$" thick)
3. Tree tex	—	—	0.13 ($\frac{1}{2}$" thick)

The fibres were mid-brown and varied greatly in fineness and length, the coarsest and longest being almost whole pine needle fibres. At frequent and regular intervals along the fibres were what appeared to be "greenstick" fractures which were probably incurred during the processing of the fibre. These "Fractures" were more apparent on the coarsest fibres.

Scanning electron microscopy

Microscopic examination of pine needle was done on the scanning electron microscope (SEM). The coarse, medium and fine fibre from pine wool were taken and examined in the SEM. The micrographs were made and the observations taken.

Acknowledgement:

The author feels much obliged to Mr. C.B. Tabb, Head Division of Paper Pulp and Division of Fibre Tropical Product Institute, London for the arrangements in getting the pine wool examined for various strength properties. Thanks are also due to Mr. C.G. Jarman, Head, Fibre Section and other members of his staff for taking the measurements for fineness tensile strength and extension characteristics and for the data on coir and sisal fibre and Mr. Roger Bons of the SEM Section for taking the Electronic micrographs. He is grateful to Dr. C.K. Atal, Director, Regional Research Laboratory, Jammu for arranging to send the pine needles samples and the keen interest he has shown during the investigation.

References

1. J.S. Chawla, Pine needle for fibre board. Regional Research Laboratory, Jammu News letter, Vol. 3 (5) August, 1976.
2. S.R. D. Guha, R.N. Madan Sirpur Industries Journal, Vol. 2 (3) Holi, 1963.
3. D. Narayanamurti, Indian Forest Bulletin No. 207, 1955.
4. Wealth of India 'Raw materials Vol..VIII, p. 69, Publication & Information Directorate, CSIR, New Delhi, 1969.
5. J.S. Chawla, Pine wool from Pine needles (unpublished work), Regional Research laboratory, Jammu News letter, Vol. 2, No. 2, 1975.
6. K. Esau "Anatomy of seed plants" p. 288-89 John Wiley and Sons Inc. London. New York, 1960.
7. Fibre board from Regional Research Laboratory, Jammu News letter, Vol. 2 (5), December, 1975.