Bagasse Fibre and its Applications

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In present era materials which extracted from renewable sources, eco-friendly, biodegradable etc. are preferred by everyone to save earth from future problems.
Bagasse is one of the most eco-friendly resources suitable for various applications, baggase fibe is extracted from sugar cane rind in two different steps: mechanical separation and chemical extraction. Further nonwoven fabric & composite sheets are manufactured from extracted fibres alone or blending it with cotton/ramie/ Polypropelene. In this article we have described basic information of baggase fibre, fibre extraction technique, manufacturing technique of baggase nonwoven & composite and its applications

Bast fibres represent fibres that are obtained from the stem or stalk of the plants. Sugar cane has stems which contain bundles of fibres, but they are not classified as bast fibres. The difference comes from the arrangement pattern of the fibre bundles; in regular bast fibres the bundles are in a definite ring pattern, while in sugar cane they are more randomly dispersed. Nowadays several varieties of sugar cane are used in agriculture. The sugar cane plants are known to grow best in tropical and subtropical regions. Sugar cane stalk characteristics vary considerably depending on variety. Typical commercial varieties grown under normal field conditions have a height of 1.5 to 3 meters and are 1.8 to 5 cm in diameter. The stalk surface can be greenish, yellowish or reddish in color and is covered with a thin waxy layer. The cane stalk is made up of shorter segments and joints. These joints vary in length from 5 to 25 cm. The lower joints are longer, larger in diameter, and older than the upper joints. Each joint has two distinctive parts, the node and the internodes. In a cross section in the internodes we can observe two distinctive areas. The first one, known as the rind, is the outer dense hard layer. The inside layer, known as the pith, is the soft light colored region where the fibro vascular bundles are embedded. The rind varies in thickness and texture along the stalk length.

Figure 1 : Bagasse Fibre

Average Bagasse Composition

Table 1

Parameter	Content in baggase (%)
Moisture	49.0
Fibre	48.7
Soluble Solids	2.3

Fibres in bagasse consist mainly of cellulose, pentosans, and lignin. Cellulose is a natural linear polymer and has polymer chains of 2000 to 3000 units and a specific gravity about 1.55. Cellulose is highly crystalline regardless of the source. The ordered chains are tightly packed and have strong intermolecular hydrogen bonding because of the preponderance of hydroxyl groups. The cellulose is present in three types: alpha, beta and Gama. The cellulose is known as pure cellulose, whereas beta and gama cellulose combined are called hemicelluloses. The hemicelluloses are chemically linked with cellulose molecules. The other main compound in sugar cane fibre bundles is lignin which is a high molecular weight substance. The apparent limitation on length of the sugar cane rind is the internodes length, and this varies from 5 to 25 cm. The length of the ultimate fibre cells is from 2 to 4 mm which contents no of fibres. The length of extracted fibre bundles depends on extraction conditions and the extraction process.

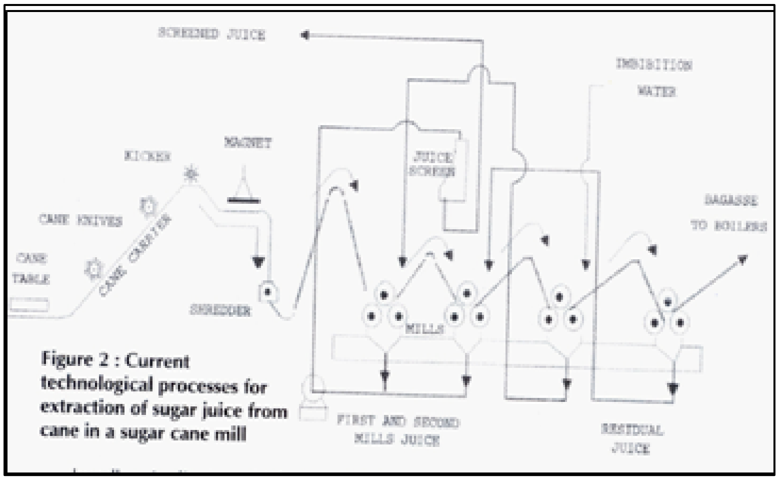


Figure 2 : Current technological processes for extraction of sugar juice from cane in a sugar cane mill

Technology of Sugar Industry:

Besides the main product, sugar juice, several by-products are available in the sugar cane extraction process. The most important is considered to be bagasse. As it can be seen in Figure 2, sugar cane is crushed in a series of mills, each consisting of at least three heavy rollers. Due to the crushing, the cane stalk will break in small pieces, and subsequent milling will squeeze the juice out. The juice is collected and processed for production of sugar. The resulting crushed and squeezed cane stalk, named bagasse, is considered to be a by-product of the milling process Bagasse is essentially a waste product that causes mills to incur additional disposal costs.

Fibre Extraction Technique:

1. Atmospheric Extraction Process to Obtain Bagasse Fibres

To extract the bagasse fibres, a series of mechanical and chemical procedures was used. Waste bagasse was laid out on the ground of an open but roofed area in a Sugar Factory for a period of two weeks. To assure a uniform drying process the layer of bagasse was turned over once a day. The moisture content was measured for randomly selected samples of fibres. The results indicated a consistent level of moisture less than 15%. Small fibres and impurities were removed through a sifting process using a 2 ft by 2 ft wooden frame sieve having a screen with 1/16 in eye dimension.

2. Chemical extraction

It is determined that the most influential factors for the extraction process were alkaline concentration, time of the reaction, mixing, and presence or absence of steam explosion. The extraction process took place at atmospheric pressure. For the alkaline extraction, an atmospheric process is employed. It is determined that a 2.0 N NaOH solution required to remove a significant amount of lignin. The measured volume of the reactor was 200 liters. The solution is heated up to the boiling point (approximately 100°C). Sifted bagasse is then fed into reactor gradually. The fibre/liquid ratios used are 1:10. In approximately 90 minutes the whole amount of bagasse, intended for delignification, and collected at the other end of the reactor. The extracted fibres were rinsed thoroughly with water and left to dry for two days in a controlled environment with a relative humidity of 65% and a temperature of 71°C.

Manufacturing Technique

1. Bagasse fibre reinforced polymer composite & its Abrasive wear behavior.

In recent years increasing attention is being given on the use of natural fibres as a reinforcing component for the thermoplastics. The advantage of natural fibres over traditional reinforcing materials includes low density, low cost, biodegradability and recyclability etc. Sometimes these tribo components are subjected to abrasive wear either by sliding against a rough counter face or abrasion by hard particles.

Sugarcane bagasse reinforced to polymeric resins and reported that composites with homogeneous microstructures could be fabricated. Bagasse fibres as reinforcement in polymer resin for tribological application. In fibre reinforced composite, structure, dimension and orientation of fibres are important factors for their tribological properties

The type of epoxy resin used is LY 556. It possesses a density of 1.1 gm/cm3. The low temperature epoxy resin and corresponding hardener (HY95l) are used. Fresh bagasse fibres were collected. These fibres were then cleaned with pressurized water to remove sugar residues and organic materials and then dried with compressed air before using them for preparation of composite. 20 % fibre volume fraction optimized for the composite. Composites were prepared by using resin to hardener ratio as 10:1. Usual hand lay-up technique was used to manufacture the composite sheet at room temperature.

Samples were cut in a standard size of 20x20x20mm3 and polished before testing on a Two-Body Abrasion Tester. Abrasive wear behavior of bagasse fibre reinforced composite in different directions, namely parallel orientation (PO), anti-parallel orientation (APO) and normal orientation (NO) by using a two body abrasion wear tester is measured. Schematic diagram of composites showing different fibre orientations and sliding direction with designations of samples are shown in Figure 4.

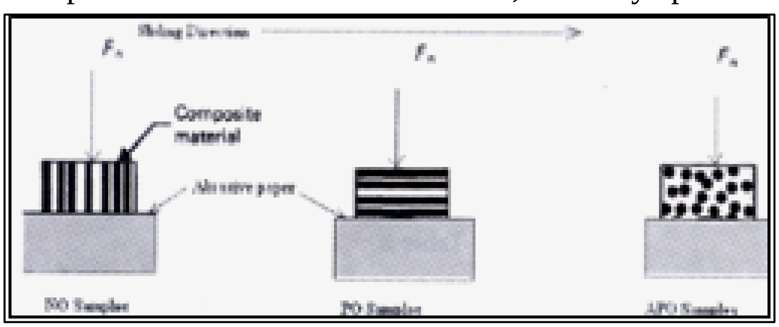


Figure 4: Schematic diagram of different fibre oriented composite with respect to sliding direction

Composites with three different orientations of fibres i.e. parallel orientation (PO), anti-parallel orientation (APO) and normal orientation (NO). The results show the PO samples had the maximum wear rate than those of the APO and NO samples but with varying magnitude at different loading conditions and grit sizes. So the wear rate follows the trend:

$W_{NO} < W_{APO} < W_{PO}$' The possibility of the real contact area with fibres in the sliding direction is more in PO samples than the APO and NO sample, which led to the highest wear.

2. Nonwovens

The extracted bagasse fibres were first cleaned using a Cleaning McPherson Machine. The cleaned bagasse was blended manually with cotton, ramie or polypropylene in different ratios by weight. For intimate blending and nonwoven web formation, a carding process was employed. The different samples were fed into a F105 D Universal Carding Machine. To enhance uniformity of the web, each combination was passed several times through the carding machine.

The web bonding was realized in two different ways. A Morrison Berkshire Needle-Punching Machine was used for mechanically bonding the bagasse/cotton/biopolyester, bagasse/kenaf/polypropylene, bagasse/ramie, bagasse/ polypropylene. The feeding speed was 5.4 ft./min and the punching rate 228 strokes/minute. Each sample was punched twice faced up and twice faced down. The carding and needle-punching processes for nonwoven fabrication were purposely chosen for the development of these structures because they have been used to make automotive interior mats that can be easily thermoformed into various shapes and molds for automotive interior trim parts.

Figure 5 : F105 D Universal Carding Machine

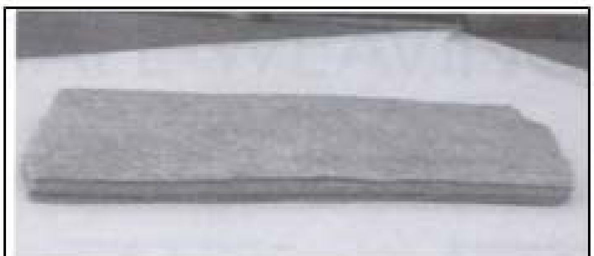


Figure 6 : Three Layer (sandwich type) Nonwoven

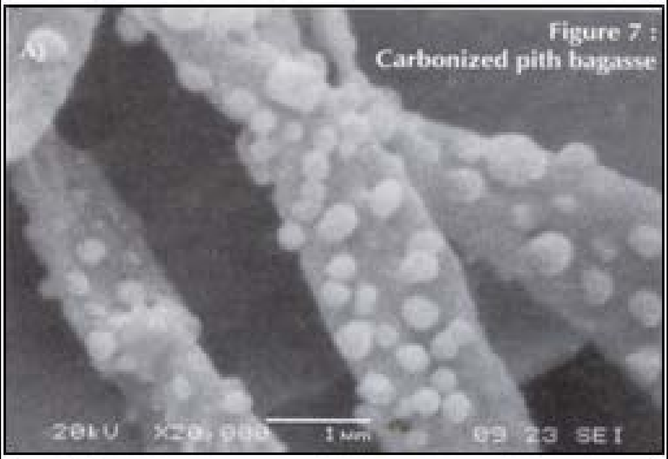
Figure 6: Three layer (sandwich type) Nonwoven Composite - Bagasse/Kenaf/Polypropylene

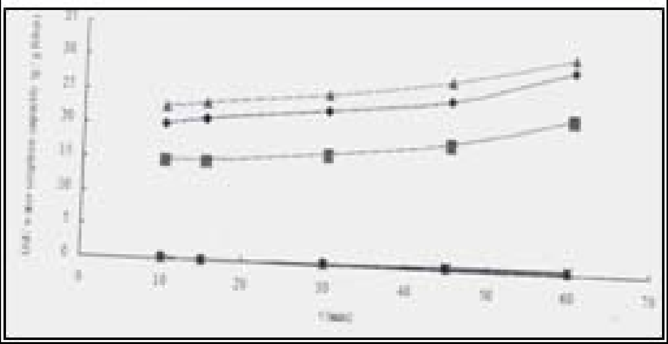
Thermal-bonding was done using a Carver Laboratory Press with heated plates. The thermal-bonding temperature was set to 150°C and the heating time was one minute. Thickness of the thermal-bonded nonwoven was set to 0.6cm (1/4") and 1.3cm (1/8"). The pressure applied was 8.62 Pa (12,500 psi). Due to the limitations of the press dimensions, the samples obtained measured 12.5 cm x 15 cm (5" x 6").

Applications

1. Oil spill sorption

This type of nonwoven material is made to provide an efficient, easily deployable method of cleaning up oil spills and recovering of the oil. Carbonized pith bagasse, material is being used as an adsorbent to remove contaminants "oil" from water. Fibres extracted from bagasse and carbonized at 300°C were found to have a high performance for sorption and recovery of light, heavy oils and even the viscous ones.





The carbonized pith bagasse is packed into a polypropylene bag and used for sorption behavior. A comparison is made between the prepared pad and the commercial sorbents. That the pad containing carbonized pith bagasse has higher sorption capacity in comparison to the commercial sorbents. The pad exhibited high oil retention ability and a high selectivity for the oils over the water. The pad shows a possibility of reuse for eight times. The sorption capacity of the pads containing carbonized pith bagasse is found to increase with increasing the time of sorption till it reaches the maximum value at the time of sorption equal to 60 min.

Figure 8: Effect of sorption time on the oil sorption capacity (g/g of bagasse fibre)

The carbonized pith bagasse has higher sorption capacity (of 25,32,30 and 23 g/g fibre) for fuel oil, seven-day weathered oil, one-day weathered oil and gas oil, respectively, when compared with the commercial sorbents which have maximum values for seven-day weathered oil of 15.8125 and 10.15 gig fibre for oil-only sorbent white sheet and adsorbe-IT filtration fabric gray sheet, respectively.

2. Agricultural End-use

Bagasse fibre nonwovens can be used to make flowerpots. This type of flowerpot has excellent biodegradability and can be buried in a flowerbed or larger plastic or clay pots. The bagasse nonwoven pot buried in flowerbed is dissolved within only 23 days. When the nonwoven pot is put in a larger plastic pot, it is biodegraded within 50 days. The study also shows that the bagasse nonwoven pot is capable of sustaining weather and watering during seedling and retailing.

3. Animal Bedding

The bagasse fibre nonwovens can be used as bedding material for poultry farms. Because the nonwoven is easy to layout and pack, the used nonwoven bedding material (after collecting enough poultry wastes) can be packed and sold as garden mulch directly. This approach not only promotes production of biodegradable and nutritional garden mulches, but also helps ease animal waste management.

4. Aquaculture

N Like other geotextiles, the bagasse fibre nonwovens can be o applied in aquaculture, such as bank weed control, filtration and pile wraps. Artificial habitats used in fish cultivation can benefit the aquaculture system by providing shelter and separation, additional nutrition and water quality improvement. Thus, availability of inexpensive artificial habitat materials can help fish farmers with profits.

5. Sugarcane Bagasse Paper

Sugarcane Bagasse is one of the most eco-friendly, sustainable, renewable resources suitable for high quality paper making. The bagasse fibre used state of the art technology to create a bagasse pulp suitable for high quality paper making. Newsprint papers are produced from 100% bagasse fibre, high quality office and printing papers have a 20% internal fibre added to ensure that the paper is suitable for all office and print applications.

Paper products fall under the following categories:

1. Paper produced from a non-forest resource (alternative fibre)
2. Paper sourced from a renewable resource (crops are constantly renewed for sugar consumption)
3. Recycled paper (as per FSC's description of papers which are considered recycled).

The following table provides some uses for bagasse pulps in papermaking.

Type of Paper	Bagasse (%)	Long Fibre Pulp (%)	Quality
Bond papers	80-90	10-20	excellent
Bristol boards	100	0	excellent
"B" grade wrapping papers	60-70	30-40	acceptable
Glassine	80-90	10-20	very good
Wood-content printing papers	80-90	10-20	very good
Wood free writing papers	0-100	0-10	very good

Conclusion:

The extraction of bagasse fibres from sugar cane does not require a complicated technological process. It was determined that the influential parameters for bagasse extraction were: alkali concentration of the solution, time of the reaction, and mechanical agitation. Different nonwoven structures were created using a minimum level of technology which are used in many applications such as Agricultural, Animal Bedding and Aquaculture.

Bagasse is eco-friendly, biodegradable fibre which is produce by less cost and having widely use in feature for many applications. Further research in this field will help to find better application of this fibre.

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