Paper & Boards from Banana Stem Waste

Problem/Need

In this modern age, the consumption of paper and boards has increased tremendously. Conventionally, paper is manufactured from cellulosic materials like bamboo, hardwood, cotton rags, etc. The ever-increasing demand, especially of the advanced countries has resulted in continued denudation of forests causing severe environmental imbalances. In this context, cellulose technologists are searching for alternative raw materials.

Agricultural residues of non-woody nature like cotton stalks, wheat straw, rice straw, sorghum stalks, hemp, jute, etc., are possible raw materials which could be used for paper and board making. However, all these require to be digested at high temperature and pressure, employing energy consumptive and costly processes. Thus the search for other raw materials and cost-effective processes continues.

One of the materials found to be promising was banana stem waste, which is a very good source of cellulose. Banana production in India is the highest, and the area under it's cultivation is second largest, among all fruit crops grown in India. About 9.8 lakh tons of dry residue is produced from this huge production, all of which goes waste due to non-availability of suitable technology for its commercial utilization. Taking into consideration the large availability of banana stem waste in the country, Dharamitra (Wardha, Maharashtra), an eco-technology group for sustainable development, took up the production of boards and thicker varieties of paper from this agro-waste.

Technology Package

A simple technology had been evolved, earlier at All India Khadi & Village Industries Association (Wardha), and later on at CSV, Wardha. It was further improved at Dharamitra. The technology for soft board has now been converted to hard board, which involves the following processes.

1. Chopping: Banana stem waste, thrown away by farmers after harvesting of fruits, is procured as raw material. The stems are chopped into small pieces of 3-4" size by a woman worker, usually at a rate of about 100 kg material per day. This can be done either at the farm itself or at the production unit.

2. Cold digestion: The material is soaked in 1-2% NaOH for appropriate period. The alkali loosens the ligno-cellulosic bonds, thereby softening the material.

3. Washing: The softened material is transferred to bamboo baskets and washed with water to remove the black liquor of sodium lignite and unused alkali.

4. Beating: The washed material is then subjected to beating in a Hollander beater. Two actions take place here: (a) initial cutting of the material into small pieces, and (b) separation of fibre from the non-cellulosic material. This is followed by a wet beating. In this process, internal fibrillation of the fibres takes place. A period of three to four hours of beating is required for a getting good quality pulp. Depending upon the quality of boards to be produced, appropriate amount of fillers, loading material or chemicals are used during wet beating. For production of hard boards, suitable quantity of resins like urea formaldehyde and phenol formaldehyde are added in the beater itself while maintaining pH.

5. Storage: After completion of beating process, the pulp is delivered to a storage tank located constructed close to the beater.

6. Board-making: Pulp from storage tank is manually lifted in a bucket and deposited in specifically fabricated wooden moulds. They are of two sizes: 26”x39” and 26”x52”. Depending on the thickness required, appropriate quantity of pulp is poured in the mould and pressed to remove excess water, using either a screw press or hydraulic press. The maximum water content desirable at wet conditions is about 60%.

7. Drying: The wet boards are then allowed to dry under direct sun on bamboo frames specially made for this purpose. About 90-95% moisture gets removed. There are soft boards.

8. Hot Hydraulic Press Treatment: To produce hard boards, these soft boards are further pressed in a hot hydraulic press at optimized temperature and pressure. The time interval depends on the thickness required.

9. Post-pressing: During the process of drying, the boards get deformed or warped. To make them flat, several boards are stacked together and pressed in a screw press for 2-3 hours.

10. Trimming: The well-pressed boards are then cut into standard sizes of 24”x24”, 24”x36” and 24”x48” and stacked for marketing.

Uses

Banana board is potential substitute for wood products like plywood and medium density boards. Various uses include:

- **Acoustic panels:** Intensive studies made by the Acoustic Laboratory of Dept. of Physics, Nagpur University, show that banana boards have good acoustic properties. The noise retention coefficient of banana boards was found to be far better than conventional boards. At present, acoustic panels available in the market cost about 18-40 per sq.ft. Boards made from banana stem will cost Rs.10-15 per sq.ft.
- **Partition walls and other utilities:** The insulating properties of these boards are found to be very good. These boards may be used for partition walls, false ceilings and as insulating panels.
- **Packing material:** Boxes made from these boards can be used for transport of fruits and other materials.
- **Files and cover paper:** Thicker varieties of banana paper can be used for making files, covers and packing materials.
- **Expansion joint pads:** Asphalted banana boards can also be used as expansion joint pads in the construction of bridges. These are much cheaper than conventional ones available in the market.

Economics

An economic analysis for small-scale production is shown in the accompanying box. Some crucial issues are revealed therein. Firstly, it must be noted that the output is of soft boards. In order to produce hard boards, additional machinery is required, comprising mainly the calendaring machine, cutting machine and hot hydraulic press. This will increase the capital cost by about Rs.5.6 lakhs for machinery apart from costs of additional power, space and covered area, manpower, etc. But on the other hand, the need for supplying soft boards to a downstream industrial unit for conversion to hard boards will be obviated, and surplus accrual will improve. This issue points to the need for further R&D on developing low cost machines for calendaring, pressing and cutting, if feasible. The second issue to be noted is that in order to achieve viability and self-sustainability, production of banana boards is supplemented by production of paper from cotton rags (both white and coloured). In fact, banana waste utilization gets confined to 100 days (of the total 300 working days) due to requirements of drying. This again points to an area

requiring further work although use of waste rags for conversion to good quality paper is also an important contribution towards environmental conservation as it relieves pressure on wood based paper production. Thirdly, the use of considerable quantities of chemicals, required mainly for rags-to-paper process, also needs to be looked at from an environmental viewpoint.

Given the large availability of banana waste and the environmental cost of conventional paper production, there is urgent need for addressing these issues in order to optimize this technology package.

Economics	
I) Capital Costs	(In Rs.)
a. Land	50,000
b. Workshed 1500 sq.ft. @ Rs.150	2,25,000
c. Equipment & Machinery (beater, screw press, auto vat, moulds)	2,00,000
d. Utilities	75,000
e. Miscellaneous	40,000
Total (I)	**5,49,000**
II) Variable Costs	
a. Raw Material/Consumables	
Chopped banana stem (20 tons)	60,000
White cotton rags for quality paper (9 tons)	1,80,000
Colour cotton rags (9 tons)	40,000
Resin, chemicals, additives	1,22,000
Packing material	10,000
Sub Total	**4,13,800**
b. Wages	
Skilled workers (5) @Rs.60/day	90,000
Unskilled workers (5) @Rs.45/day	67,500
Female workers (5) @Rs.45/day	67,500
Sub Total	2,25,000
c. Indirect expenses	
Interest on working capital	10,000
Utility charges (water & electricity)	50,000
Marketing cost (5% of total sale)	51,775
Sub Total	1,11,775
Total (II)	**7,50,575**
III) Fixed Cost	
Supervision and overheads	40,000
Depreciation	31,000
Interest on term loan	57,000
Total	**1,28,000**
IV) Income (27 tons finished product; 90% capacity utilization; total sale)	
Soft board: 9 tons @ Rs.35,000/ton	3,15,000
Cover/file paper: 9 tons @ Rs.30,000/ton	2,70,000
Quality paper 9 tons @ Rs.50,000/ton	4,50,000
Total	**10,35,000**
Cost of production: Variable Cost + Fixed Cost	**8,78,575**
Gross Surplus: Total Sale – Cost of production	**1,56,425**
Net Surplus: Gross Surplus – Depreciation	**1,25,425**

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