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Currency Note Paper and Banana Fiber Pulp Waste Utilization and its Effect of Density, Moisture and Temperature on Wood Products

Ashok G. Matani, Premesh P. Bhatkar, Shamal K. Doifode

Abstract: ***Possibilities for use of banana fiber and currency notes thermally modified groups were evaluated for the production of plywood boards in industrial conditions. Formats of groups were treated at temperatures of 190 °C, 200 °C, 210 °C, and 215 °C for each 9 h to making the pulp process. By combining the treated and non-treated formats of veneer in types of board groups, thirteen different types of board were made. Analysis showed that the examined physical and mechanical properties were influenced by both the type of construction and the applied thermal treatment. Boards composed only of thermally modified group achieved the best results regarding moisture absorption and dimensional stability, and boards composed of the combined currency notes and banana fiber had better mechanical properties. As per the analysis of plywood board when used banana fiber used in pulp of plywood board is suitable at190 °C temperature rather than 215 °C temperature with comparing the other types of board. 25 °C temperature is less requires for control group board. We can consume cost of heat which is used in this process and getting the hard quality of plywood. At 215 °C temperature of processing cost of heat is 10% of plywood cost and when at 190°C of processing the cost of heat is 9.06% of plywood cost so that we can consume 0.94% cost of heat. Moisture content of temperature conditioned boards of control group is 9.01% density of conditioned boards 436.36 kg/m^3. Highest bending strength and modulus of elasticity of boards is 48.07MPa and 6078 MPa in longitudinal direction and bending strength and modulus of elasticity of boards in cross-section 28.40MPa and 2027 MPa.***

Keywords: Currency wastage notes, Banana Fiber, waste management, wood pulp, composite material pulps, plywood boars.

I. INTRODUCTION

When considering how energy is stored, used, and controlled, mechanical engineers have to consider a large spectrum of possibilities. There are many energy sources like oil, natural gases, wind, water, and many more that can all be applied in different ways. Banana is one of the important fruit crops cultivate in tropical part of the world. Banana farming generate huge quantity of biomass all of which goes as wastage and the above ground part like pseudo-stem and peduncle are the major sources of fibers. Banana fiber can be used as raw material for industry for production of range of products like paper, cardboards, tea bags, currency notes and reinforced as polymer composite in high quality dress materials. Cellulose is the major component of the fiber. Today engineering industries are seeking to produce eco-friendly materials. Natural fibers have distinct properties like high strength, low weight, low cost processing and bio degradability than synthetic fibers such as glass fiber and carbon fiber. In order to achieve these principles, this research aims to develop a new strategy called Banknote for Banknote (BFB), which aims to recover and refine cotton from Banknote waste and later reuse it again in the production of banknote paper or reprocess it into cellulose nano-crystals suitable for use in many advanced applications through a sustainable technology. In any dynamic system, energy must be stored and used at some point and, therefore.

Thermodynamics and heat transfer are two of many topics that mechanical engineers study and are concerned about in a design including an energy system Banknote printing is the industry that has a deep influence on financial operations on market, reflecting the economic performance of governments. This waste contains significant amounts of cotton, percentage of which sometimes can reach up to 99.3% of the weight of banknote paper. It is clear that disposal of such waste by simply incinerating it contrary to the principles of sustainability and preservation. Nearly a month before the demonetization of Rs 500 and 1000 currency notes, the RBI officials started supplying the shredded notes to the plant after they successfully did the pulping during the trial run and then the regular flow of the shredded notes started. Since the paper could not be used in huge quantity to make the boards, there is a limit in using the shredded notes, and as of now around six metric tons of shredded notes are used a day in the plant. Somewhere between 5 and 15 percent of the pulped currency is added to the wood pulp in order to make the boards. Though it adds strength to the boards, the issue is that it has to be cooked in high temperature and pressure to make it pulp using thermo mechanical pulping, and hence the process is bit too long, said the technical staff in the plant.

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* Correspondence Author
Dr. Ashok G. Matani*, Professor, Department of Mechanical Engineering, Government College of Engineering, Amravati, India
Premesh P. Bhatkar, PhD NDF Scholar, Department of Mechanical Engineering, Government College of Engineering Amravati, India
Dr. Shamal K. Doifode – HOD- Department of Chemistry, Government College of Engineering, Amravati, India

II. MATERIALS AND METHOD

For this experimental study the materials used in this study are banana fiber pulp, currency notes pulp and wood pulp with a nominal thickness of 3 mm. The banana fibers were selected by random sample method from the storage of plywood mill Navasari agriculture university (NAU) in Gujarat. The materials were shipped to laboratory facility of the company same unit. Based on the previous laboratory research, it was found that thermal treatment at 215 ºC for 90 min gave the optimal ratio between the loss of volume shrinkage and the loss of mass of banana fiber (loss of shrinkage was 7.62 % and loss of mass was 6.49 %). Most of the material was thermally treated by the above regime and some of the material was left untreated for the production of control samples. Thermal modification was conducted in the presence of steam as protection agent, so the treatment can be assumed as steam-heat treatment. In the treatment regime, the conditioning phase was also included in addition to heating phase, thermal treatment phase and cooling phase. The conditioning phase of 2-hour duration started at the moment when the temperature dropped below 100 ºC. After thermal modification, banana fiber sheets were cut into 80 mm and prepared for pressing. Melamine urea formaldehyde adhesive was applied by hand roller-spreader by spreading rate of 200 g/m^2, fiber were arranged into the corresponding lay-ups and pressed according to the following regime: pressing temperature t = 85 ºC, total pressure P = 15 MPa, pressing time Z=10 min for three-layer plywood and Z=13 min for five-layer plywood. Four samples of 5 cm by 5 cm were cut from each panel the mass and dimensions of all samples were measured and dried to oven-dry condition, and measured again. Based on the measurements, the board moisture content and density were calculated. After measurements, the samples were arranged in closed containers above water and the changes in their MC and dimensions were monitored. The measurements of mass (for MC calculations) and thickness were performed every day during the first week, and after months.

III. RESULTS AND DISCUSSIONS

A statistical analysis showed that there were significant differences in the achieved moisture content among most of the boards. With higher treatment temperatures and a higher share of thermally modified sheets of veneer in boards, values of absorption were lower as shown in Table 1. Accordingly, the boards had different reactions to the same air humidity. The type of board construction and veneer treatment temperature both influenced the equilibrium moisture content of the boards. The decrease of hygroscopicity with the increase of treatment temperature was expected because the number of hydroxyl groups decreases during thermal treatment. This is one of the reasons why the equilibrium moisture content was lower in boards with larger shares of thermally modified veneer.

Table 1: Moisture content of temperature conditioned plywood boards

Board Type/ Schedule	190 °C	200 °C	210 °C	215 °C
Control group	9.01% (0.33)	9.0%(0.28)	8.88% (0.26)	8.86% (0.21)
T3NT	8.82% (0.21)	8.37% (0.19)	8.31% (0.34)	8.12% (0.37)
TNTNT	8.16% (0.29)	7.79% (0.25)	8.05% (0.29)	7.41% (0.30)
5T	7.72% (0.22)	7.32% (0.32)	6.54% (0.30)	6.31% (0.30)

With an increase of treatment temperature, the moisture content of boards made only of thermally modified veneer (5T) was lower than that of the control by 2.42%, 2.76%, 3.97%, respectively. The great decrease of moisture content (almost 3.97%) between treatments at 200 °C and 210 °C potentially indicated a significant structural collapse of poplar veneer treated at 210 °C. In control group standard deviations value is larger than other group of the plywood as well as the mean value of moisture content is more than other groups.

These differences were mostly related to the density decrease of boards made out of sheets treated above 200 °C as compared to the control boards. One possible explanation is that an increase in treatment temperature leads to a decrease in the density of poplar veneer. The densities of other compared boards did not show distinct significant dependence on board construction or the applied thermal treatment as shown in Table 2.

Table 2: Density of conditioned plywood boards (kg/m^3)

Board Type / Schedule	190 °C	200 °C	210 °C	215 °C
Control group	436.36 (11.21)	419.65 (13.32)	320.87 (35.35)	313.13 (32.24)
T3NT	414.22 (25.83)	419.65 (13.32)	420.87 (35.35)	393.13 (32.24)
TNTNT	424.55 (18.32)	424.21 (32.43)	400.26 (29.80)	393.84 (24.53)
5T	404.46 (13.64)	411.04 (13.69)	388.64 (27.79)	378.21 (10.52)

The mean values of shear strength and the percentage of cohesive wood failure, along with an assessment of whether or not the criteria of the standard were satisfied. Examinations were conducted for three types of water resistance: boards for dry conditions, boards for humid conditions, and boards for exterior conditions as shown in Table 3.

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Table 3: Possibilities of board application in dry, humid, and exterior conditions

Test		Dry			Humid			Exterior		
Board Type / Schedule		σ (MPa)	W (%)	Pass	σ (MPa)	W (%)	Pass	σ (MPa)	W (%)	Pass
Control group		1.603	67.92	✓	1.220	16.25	✓	1.095	5.42	✓
190 °C	T3NT	1.488	71.17	✓	1.016	2.50	✓	0.803	1.25	X
	TNTNT	1.228	39.36	✓	0.701	12.50	X	0.624	1.67	✓
	5T	1.326	82.14	✓	0.770	6.67	X	0.675	8.33	X
200 °C	T3NT	1.417	66.94	✓	1.018	13.75	✓	0.843	15.83	X
	TNTNT	1.397	76.50	✓	0.905	9.17	X	0.763	9.47	✓
	5T	1.141	76.50	✓	0.753	13.75	X	0.719	4.17	✓
210 °C	T3NT	1.150	56.00	✓	0.947	33.91	X	0.970	23.64	X
	TNTNT	1.232	60.00	✓	0.741	14.82	X	0.735	19.17	X
	5T	0.883	49.09	✓	0.674	19.05	X	0.634	17.08	✓
215 °C	T3NT	1.231	62.22	✓	0.876	24.50	X	0.825	20.23	X
	TNTNT	1.005	50.78	✓	0.724	25.45	X	0.720	24.91	X
	5T	0.837	52.22	✓	0.626	23.00	X	0.588	21.86	✓

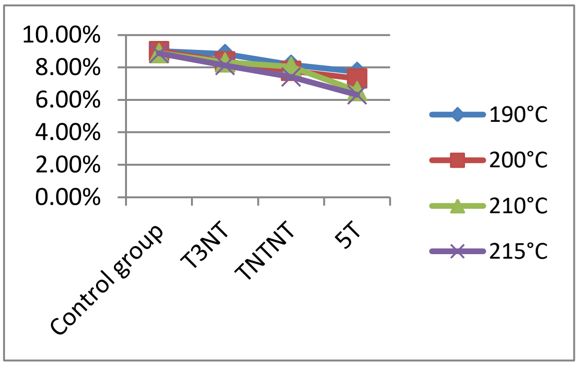

Figure 1: Percentage of moisture contain in plywood board

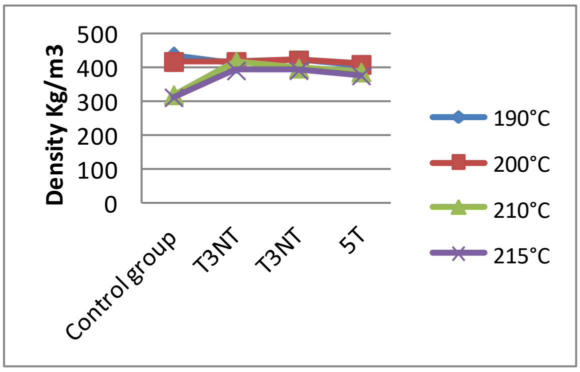

Figure 2: Density contain in plywood board

IV. CONCLUSIONS

Banana fibers have shown high variability along the length and between fibers, which is a characteristic of natural fibers. The main objective of this study was to establish the suitability of banana stem fiber as a potential source of lingo-cellulosic fibers for plywood Board making. Plywood-making properties were characterized by low strength. The examined physical and mechanical properties of plywood were affected both by the schedules of thermal modification and plywood construction types. Boards made of veneer treated at higher temperatures, as well as boards that contained more thermally modified veneer, had lower equilibrium moisture content and lower swelling across their thickness, but also weaker mechanical properties in comparison with the control boards.

The banana fiber density value was very high with high roughness. The air permeability was moderate. Compare with other raw materials, the optical properties were found to be extremely good. Because of the high quality of its pulp, it is suitable for fine plywood board making. However, there is scope for further research to completely characterize the banana fibers and facilitate proper applications in paper/plywood board industries.

As per analysis of plywood board when used banana fiber used in pulp of plywood board is suitable at 190 °C temperature rather than 215 °C temperature with comparing the other types of board. 25 °C temperature is less requires for control group board. We can consume cost of heat which is used in this process and getting the hard quality of plywood. At 215 °C temperature of processing cost of heat is10% of plywood cost and when at 190°C of processing the cost of heat is 9.06% of plywood cost so that we can consume 0.94% cost of heat. Moisture content of temperature conditioned boards of control group is 9.01%. density of conditioned boards 436.36 kg/m3. Highest bending strength and modulus of elasticity of boards is 48.07MPa and 6078 MPa in longitudinal direction and bending strength and modulus of elasticity of boards in cross-section 28.40MPa and 2027 MPa.

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AUTHORS' PROFILE

Dr. Ashok G. Matani is Ph.D. (Mech. Engg). MBA (Marketing) Having total (Academic, Research, Administrative & Industrial) = 28 Years. Areas of Interest included Energy Conservation, Industrial Engineering, Productivity, Industrial Management, Operations Management, Entrepreneurship, Water, Conservation and Environment. He had presented/ published more than 100 papers in IITs /NITs/ IIMs and chaired sessions and Delivered keynote addresses in various conferences.

Premesh P. Bhatkar is Ph.D. NDF Scholar, M.Tech Thermal Engineering in Department of Mechanical Engineering, Government College of Engineering Amravati [MS].Presented / published more than 10 papers in International / National Conferences organized in IITs NITs. Published paper in Scopus Indexed journal and awarded best paper in International Conference in NIT Trichy.

Dr. Shamal K. Doifode is presently working as HOD- Department of Chemistry, Government College of Engineering Amravati [MS].Presented / published more than 40 papers in International / National Conferences organized in IITs NITs. Published papers in Scopus Indexed Journal worked as Session Chair in various International Conferences in NITs.