Techno-Economic Analysis of Wood Waste Utilization in the Manufacture of Wooden Souvenirs

[1]O.Y. Ogunsanwo, [2]A.A. Aiyeloja and [1]T.O. Akerele
[1]Department of Forest Resources Management, University of Ibadan, Nigeria
[2]Department of Forestry and Wildlife Management, University of Port Harcourt, Nigeria

Abstract: Four selected wood species; *Mansonia altissima* (Mansonia), *Nauclea diderichii* (Opepe), *Triplochiton scleroxylon* (Obeche) and *Khaya* sp. (Mahogany) were used for the production of five wooden turned souvenir products viz; bowl covers, tea cups and saucers, flower vases, snack bowls and trays. Each souvenir product type was produced at two laminate dimension levels and four species combination levels. The compatibility tests i.e., moisture content ranges between 7.55 and 24.68%, shrinkage ability between 2.16 and 6.83% and specific gravity between 0.41 and 0.73%. Profitability analysis i.e., rate of returns on investment ranges between 66.7 and 150% and the benefit-cost ratio 1.87:1. *Mansonia altissima* has the least moisture content which had an effect on the spreading and absorptive ability of glue on the wood surface; it was therefore placed at the edges, while *Nauclea diderichii* which has the highest shrinkage level which may lead to its splitting apart as time goes on was placed in between the other laminates. The specific gravity of the four species is close which makes them physically compatible as laminate members. The profitability analysis and the benefit-cost ratio showed that wooden souvenir production is both profitable and viable as a small scale enterprise.

Key words: Techno-economic analysis, wood waste utilization, wooden souvenirs

INTRODUCTION

As the world population increases, the demand for wood and wood products also increases. The world population is projected to be more than double by the end of this twenty first century, with a commensurate increase in the demand for forest products. This ever increasing need for wood by man had precipitated various painstaking researches into the properties of wood so as to analyze its economic, technological and adaptive modes of uses. It is a known fact that there is great increase in the supply of small diameter log in most sawmills in the country now as a result of over exploitation. Also various analysis carried out to measure both the technological and economical measure adopted to curb the problem of wood waste have really been of help to the environment and has led to an increase in the income generated from wood waste utilization. Forest wood utilization may be improved by giving more attention to logging, conversion and other manufacturing and utilization conditions and not rejecting naturally defective logs when the defects are not detrimental to the specific uses. Off-cuts and small sized materials can be utilized in other ways including glued laminated and

turned wooden souvenirs items as products of high utility values so as to increase the utilization of sawn timber from about 33-47% to a higher figure. Though turning activities used to be small units in the wood utilization department of some private and public establishments among which are the Forest Research Institute of Nigeria (FRIN) Ibadan and the Department of Forest Resources Management, University of Ibadan to mention a few. But nowadays, it is a common establishment in every nook and cranny of the market. Recognition of the usefulness of wood came into being as a result of its mechanical properties and other related features whether it is in the form of solid wood, plywood, laminated wood, particle boards, fibre board, paper board, turneries etc. Woods of various sizes and types are known to be useable as raw materials in the production of items such as boards' products, laminated wooden souvenirs, turneries and adhesives. Small size wood (off-cut) could be used as substitute in some and used in place of large size logs. The total absence or lack of laminating and wood turning factories in the 50s and early 60s of the last century has in recent years led to an increasing concern in wood based industries. To this intent; many people, departments have been motivated to devote a highly proportion of their resources to laminated

Corresponding Author: A.A. Aiyeloja, Department of Forestry and Wildlife Management, University of Port Harcourt, Nigeria

wood products. Turning as branch of wood work deals with conversion of wood items into different shapes figures and designs[1]. In Nigeria, laminated turned products are used domestically as bowl covers, trays, plates, materials for indoor games e.g. chess-board, draught board Ayo game, wooden frame decorations and sculptures etc in offices and most homes as ash-tray, wall plagues, wooden frames (souvenirs) and flower vases. It is used by the police as batons and as artificial limbs in medical practices. Laminates for wooden souvenirs can only be possible if members are compatible. Compatibility is the ability of different wood species members forming a desired structural laminate to tolerate one another and exist as a composite unit when glued together. The objectives of the sudy include; production of wooden souvenirs from glue laminated wood pieces, investigation of species compatibility of the laminate components and identification of the economic advantages of using wood waste for souvenir production.

MATERIALS AND METHODS

Top-bond general purpose white glue was used for gluing all the laminates and a polyguard nitrocellulose thinner was used during the turning. Polish was used for finishing. Measuring tape, pencil and iron square were used to carry out detailed measurement of the partings, width, core, length and thickness of the various turned items. The laminates for each dimension level product were pressed after gluing with the aid of iron clamps. Wood species selected and used for the study are: *Nauclea diderrichii, Mansonia altissima, Triplochiton scleroxylon, Khaya* sp.

Tools and machine used: The turning machine used was lathe. It belongs to the Department of Forest Resources Management, University of Ibadan. A Wadkin-Bursgreen Lathe model with 750 mm (2'6") centers and two speeds. The machine is used in holding and rotating of woods against hand held cutting tools (chisel) to products a circular, cylindrical and molded shapes.

Specific gravity test: The specific gravity of a wood is the ratio of weight of the wood to that of an equal volume of water. Using this formula, it can thus be expressed as:

$$G = \frac{1}{\dfrac{Ws - Wo}{Wo} + \dfrac{1}{1.53}}$$

Where   G   =   Specific gravity
          W   =   Saturated weight of wood
          Wo   =   Weight of oven dry wood

Shrinkage test: A wood does not begin to shrink until the moisture content in the cell wall has been reduced below the fibre saturation point. Such dimension changes are traditionally expressed as a percentage of the maximum dimension of the wood. To determine the shrinkage ability of the species, the formula below was used.

$$S = \frac{Ds - Do}{Ds} \times 100$$

Where   Ds   =   Dimension at saturated condition
        Do   =   Dimension at oven- dry condition
        S   =   Shrinkage

Moisture content: Weight of water contained in the wood, expressed as a percentage of the weight of the oven-dry wood i.e.,:

$$MC = \frac{Wi - Wo}{Wo} \times 100$$

Where   MC   =   Moisture content
        Wi   =   Weight at saturated condition
        Wo   =   Weight of the oven dry wood

Conversion of species for turning: The conversion of the wood species was done after planning the woods to provide smooth surfaces for gluing. The wood species were converted to laminate dimensions which are thereafter used for the souvenirs production.

S/No.	Products	No.	Lamination dimensions
1	Tea cups	10	6 feet 5 inches
2	Saucer	10	6 feet 3 inches
3	Flower vase	3	3 feet
4	Trays (medium)	5	5 feet 6 inches
5	Trays (big)	2	2 feet 4 inches
6	Bowls	5	3 feet 4 inches
7	Covers	5	2 feet 6 inches
8	Snack bowls	5	2 feet 6 inches

Each of the laminated block specimens were further cross-cut into the following dimensions;

S/No.	Products	Lamination dimensions
1	Tea cups	8 inches by 4 inches
2	Saucer	7 inches by 1.5 inches
3	Flower vase	11 inches by 5 inches
4	Trays (medium)	12 inches by 1.5 inches
5	Trays (big)	14 inches by 2.5 inches
6	Bowls	8 inches by 4 inches
7	Covers	5 inches by 1 inch
8	Snack bowls	5 inches by 2 inches

Profitability analysis: The profitability of the production of the wooden souvenirs was calculated using the Rate of Returns on Investment (RORI)

$$RORI = \frac{TR - TC}{TC} \times 100$$

Where TR = Total Revenue (Selling Price)
　　　 TC = Total Cost (Production Cost)

The viability of the enterprise was also determined using the cost-benefit analysis.

For any enterprise to be economically viable, the benefit-cost ratio must be greater than 1. The formula is given as:

$$B/C = \frac{\sum\limits_{t=0}^{t=n} \dfrac{R_t}{(1+r)^t}}{\sum\limits_{t=0}^{t=n} \dfrac{C_t}{(1+r)^t}}$$

Where R_t = Revenue over time t
　　　 C_t = Cost over time t
　　　 r = Discount rate (14%)
　　　 1 = Constant t = 1 year

Production Cost is the sum total of the cost of wood species used, finishing materials, transportation and labour.

RESULTS

The four species (i.e., *Mansonia altissima, Triplochiton scleroxylon, Nauclea diderrichii* and *Khaya* sp.) were planned and cut into a cube-like shape of about 2 by 2 cm^3 for carrying out the following tests.

- Moisture Content (MC)
- Shrinkage test
- Specific Gravity (SG)
- Profitability analysis
- Benefit-cost ratio
- Production cost

From Table 1 above, the moisture content range agrees favourably with that of Wariboko[2] who put the range for moisture content of compatible laminates between 7-20% giving room for little variations due to environmental and seasonal differences. There is also a wider variation in shrinkage level compared with specific gravity. Table 2 shows the result of profitability analysis of the various products obtained from the laminated

Table 1:　Showing moisture content, shrinkage test, specific gravity, means and mean deviations of the selected species

Samples	Wood species	Trade name	MC (%)	Shrinkage (%)	SG (%)
A	*Triplochiton scleroxylon*	Obeche	24.68	4.12	0.41
B	*Mansonia altissima*	Mansonia	7.55	6.83	0.52
C	*Nauclea diderrichii*	Opepe	21.08	2.16	0.73
D	*Khaya* sp.	Mahogany	21.72	6.71	0.65
Mean				4.96	0.58
Deviation				1.12	0.01

Table 2: Showing the rate of returns on investment (RORI) of the product

Products	No Produced	Rev/ Prod (₦)	Cost/ Prod (₦)	TR (₦)	TC (₦)	RORI (%)
Cups and Saucers	10	500	300	5000	3000	66.7
Cover Bowls	5	2000	1000	10000	5000	100.0
Flower vases	2	1000	600	2000	1200	66.7
Snack Bowls	7	500	200	3500	1400	150.0
Trays	7	1500	850	10500	5950	76.5
Total				31000	16550	

Table 3: Showing benefit-cost analysis

Total Revenue ₦	Discounted TR₦	Total cost ₦	Discounted TC₦	Benefit-cost ratio
s31000	27192.98	16550	14517.54	1.87:1

turned wood. General breakdown of the cost of production shows that wood purchase took 43.8%of the total cost (₦7250) and wood polish and glue, 41.1% (₦6800). Transportation (₦700) is 4.2% and labour (₦ 1800) 10.9%. The highest rate of returns was recorded in snack bowls and the least in cups and saucers. However, the business is very profitable because the lowest rate of returns on investment is 66.7% which makes it profitable even when loan is obtained from the Bank at rate as high as 25% or even 50% which is arbitrary. Table 3 shows the benefit cost ratio to be 1.87:1 which make the enterprise a viable one.

CONCLUSION

There is no doubt that, the waste from wood can further be utilized for some souvenir production. This has also thrown more light on the use of laminated turned products and how profitable this could be. The moisture content, shrinkage level and specific gravity were used to analyze the compatibility level among the four selected species. The lower the shrinkage percentage, the higher the shrinkage level which often leads to splitting after a period of time. This is why Obeche is rather sandwiched in between the other species rather than staying at the edge. Also Mansonia has the lowest moisture content of the four species. This has impacts on the colour of the wood which makes it beautiful at the edges of the

laminates. Lastly, though it is highly profitable and viable to invest in the production of wood souvenirs making use of wood wastes, the machines used are expensive and this might be difficult for a low income earner to acquire. This is where the Government has to come in. This may be in the form of loans, subsidies and cooperative empowerment.

REFERENCES

1. Stoke, G., 1993. Modern Wood Turning. Evans Brothers Limited, London.
2. Wariboko, I., 1986. Wood Turning Materials and Methodology, with special reference to Afroware and Co. Ltd.