Journal of Engineering Science and Technology
Special Issue on ISCoE2024 Vol. 20, No. 1 (2025) 177 - 184

PARTICLE BOARD FROM RUBBER WOODS: CONCEPT, TECHNOLOGY, COST ANALYSIS, AND APPLICATION FOR TEACHING AIDS IN SCIENCE SUBJECTS IN ELEMENTARY SCHOOLS

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Abstract

This research aims to analyse the feasibility of making particle board from wood dust as a raw material and using it for science teaching aids in elementary schools. Science teaching aids such as mini generators or moving wheels are often used in elementary schools , e.g. for teaching about changes in motion energy. This research is motivated by the large number of teaching aids that are not suitable in terms of function and quality, as teachers are not confident in choosing good teaching aids due to limited funding and unable to make their own teaching aids due to the lack of practical and financial knowledge. This research analyses several economic calculations that can be used as a basis for producing good quality particle board including a financial analysis for each step in the particle board production. This research found that 1 sack of sawdust can produce 1 particle board with a price of around Rp. 320,000; To be able to produce small scale particle board without risk of loss, at least 5 sacks of powder are needed in one production run. For this small scale, at least 5 workers, 4 types of equipment machines, 6 types of production materials are required. This small-scale work process takes at least one month for one production run. Under normal conditions without significant obstacles, with the use of quality materials and production equipment, the production of particle board made from wood powder can be profitable.

Keywords: Economy, Engineering, Particle, Rubber woods, Science.

1. Introduction

Particle board is a panel product made of wood particle powders or other types of powders such as bagasse. The particles of these powders are firmly bound into a solid structure using a so-called adhesive. Types of particle board can differ greatly in terms of particle size/ shape and the amount of resin used. The density of the panels can greatly influence the quality of the particle board [1]. Particle board is widely used as a material for making various learning aids in elementary schools. Sugarcane bagasse is often used as a raw material, because it has a high lignocellulose content. Previous research has found that using teaching aids made of particle board can increase learning effectiveness in the classroom and motivation of students [2]. This is due to the tangible nature of the teaching aids which can facilitate understanding of abstract concepts in science [3].

Using wood waste as a raw material for making particle board reduces negative impacts on the environment and increases the economic value of the wood waste.. Optimizing this process can lead to a reduction in waste and a more efficient and effective utilization of resources [4]. Particle board made from wood powder and certain types of adhesive has been proven to have advantages in terms of lower production costs and flexibility of the board. Particle board is suitable for use in various applications, including as a basic material for science education teaching aids in elementary schools. The use of particle board teaching aids in science subjects, such as Natural Science can increase the interactivity of students and their understanding of scientific concepts [5]. In environmental situations, the use of wood waste as material for the production of particle board sancta can help to reduce the amount of waste in landfills and to reduce deforestation [6, 7].

There has been a lot of research on the techno-economic use of various waste products from industrial or household waste such as paper, plastic, food waste and other waste. Several studies have been conducted on techno-economics, such as oil waste [8], electrolysis [9], LaNi5 particles [10], agricultural wastes [11], and bibliometric techno-economic research in the field of education [12]. Techno-economic analysis is a method that is used to study the business that will be run in depth, in order to determine whether or not the business is feasible when operated. Business feasibility studies have the following objectives: (i) Avoiding the risk of loss. This objective aims to avoid any risk of loss that could occur during the production process, in order maximize the benefit. The focus of a feasibility study is to minimize risks which may be undesirable, as all risks can be controlled, (ii) Ease planning. Planning can be eased by outlining future perspectives. Planning analysis in making products can include the following factors: the amount of costs required, the target time for the production business to be carried out, the people who will carry it out, work techniques, the profits to be obtained, as well as how to monitor to avoid losses, and (iii) Ease work load. Business people usually have specific guidelines for running their business. This results in their work having clear guidance and direction for each step that will be carried out. If including monitoring and evaluation in the process ensures that it is carried out well and continuously.

Based on our previous studies [13-15]. This research aims to analyse the feasibility of making particle board made from wood dust as a raw material for making science teaching aids in elementary schools, such as mini generators or moving wheels for learning about changes in motion energy. The research was motivated by the large number of teaching aids that were not suitable in terms of

function and quality. Furthermore, teachers are hesitant to choose good teaching aids due to limited funding and to make their own teaching aids due to lack of practical knowledge and knowledge of costs. This research analyses several economic calculations that can be used as a basis for producing good quality particle board. This includes a financial analysis required for each step in its production. To the best of our knowledge (i) the utilization of rubber woods as a material for making teaching aids for science subjects, and (ii) an overview of the prospects for the rubber woods industry have not been researched.

2. Literature Review

The stages of making a mini generator moving wheel board from rubber woods are shown in Fig. 1. The process of processing rubber wood into particle board includes the following steps: stage 1, rubber wood is combined with bamboo particles, stages 1 and 2 are the process of combining rubber wood using commercial equipment then mixed with wood liquids adhesive, stages 3 and 4 are mat forming stages (stage 5) again. So that it can be shaped and conditioned so that it gets the desired shape (stage 6), stage 7 is the process of forming physical and mechanical testing.

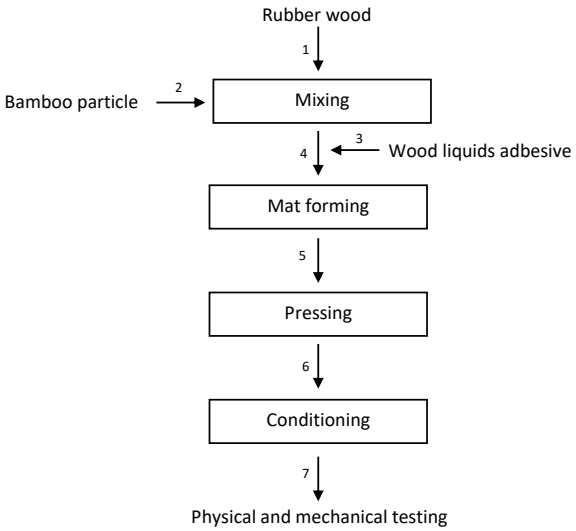

Fig. 1. Flow chart of manufacture of particle board for the basic structure of the mini generator.

3. Method

For this study we used economic analysis calculation methods of the past 20 years. We used economic analysis to calculate the production potential of portable boards from rubber woods and bamboo list. Factors included were: gross profit margin, rate of return, break-even point (BEP), and others. For data analysis we used the average price of products that are available on online shopping websites. For this analysis we used simple mathematical calculations in order to define projections of business prospects, labour costs, capital to purchase necessary raw materials, and interest rates. Detailed information on calculations has been described [16, 17].

4. Results and Discussion

The process of making portable boards as basic materials for making science teaching aids in elementary schools can be simplified by the suggested strategies. The suggested materials generally available and easy to obtain. Furthermore, these materials are inexpensive. Also, for the production of durable boards , only a small number of materials are needed. Material requirements and associated costs are shown in Table 1.

Table 1. Required materials.

No	Raw Material	Requirements Per Small Scale Production (Kg/ Hour)	Unit	Unit Requirements per Large Scale	Cost (IDR)	Total (IDR)
1	Wood particles	5	kg	5	250,000	1,250,000
2	Bamboo list	10	Liter	10	15,000	159,000
3	Wood resin catalyst	5	Liter	5	72,000	360,000
4	Liquid adhesive	20	Liter	20	92,000	1,840,000
			Cost/ day			36,000,000
			Cost/ day			86,000,000

In Table 1, 5 kg of wood powder is needed to produce one particle board production, 5 kg of this powder requires around 10 bamboo lists, 5 L of resin catalyst and 20 liters of liquid adhesive. For all these basic materials, around 36 million rupiah is needed. Furthermore, the tools necessary for production are inexpensive. Also, all of these tools will become capital for the company after initial use and can be used for production for approx.. 5 years. The necessary production equipment is shown in Table 2. In the processing and production of particle board, several tools are also used to ensure smooth production, including: chopping machines, wood powder grinding machines, wood cutting machines and wood powder gluing machines. To get 1 small scale chopping machine, around 8,000,000 is needed; Meanwhile, to get a cutting machine you need 1 million rupiah/machine.

The production of portable boards requires seriousness in production, to be able to produce the best board production, quality materials and tools are needed. Production carried out on a small scale in the manufacture of portable boards as material for making mini generator props requires several production items related to materials, tools, workers and other. Table 3 factor for estimating manufacturing cost.

Table 2. Tools.

No	Tools Name	Unit Cost (IDR)	Qty	Total cost (IDR)
1	Shredding machine	8,000,000	2	16,000,00
2	Small scale cotton powder	5,000,000	2	10,000,00
3	Small scale cutting machine	1,400,000	2	2,800,000
4	Mini wood cutting machine	1,000,000	1	1,000,000

Table 3. The factor for estimating manufacturing cost.

No	Item Total Life Time	Factor	Price (IDR)
		20 Years	
1	Raw Material		43,200,000.00
2	Utilities		58,560.00
3	Loan Interest	7% of loan	-
4	Operating Labor		60,000,000.00
5	Labor related cost		
	a. Payroll overhead	30% of labour	18,000,000.00
	b. Supervisory, misc. labour	25% of labor	-
	c. Laboratory charges	12% of labour	-
6	Capital related cost		
	a. Maintenace	6% of labour	3,600,000.00
	b. Operating sipplies	15% of mainranance	540,000.00
	c. Environmental	15% of (equipment)	4,470,000.00
	d. Depreciation	10% of (FCI)	16,204,240.51
	e. Local taxes, insurance	4% of (FCI)	6,481,696.00
	f. Plant Overhead cost	100% of (OL)	162,042,405.12
7	Saled related cost		
	a. Packaging	1% of sale	5,250,000.00
	b. Administration	2% of sale	10,500,000.00
	c. Distribution and marketing	2% of sale	10,500,000.00
	d. Research and development	1% of sale	5,250,000.00
	e. Patents and royalities	1%of sale	5,250,000.00
	Total Product Cost (TPC)		**351,346,901.84**

The overall expenditure required to produce portable boards on a small scale (see Table 3). Some things that are needed from start to finish are: Raw materials, loan interest, labor operations, labor-related costs, overhead payroll, supervision, labor, laboratory costs, capital-related costs, maintenance, material supplies, environment, depreciation, local taxes, insurance, factory overhead costs, sales related costs, packaging, administration, distribution and marketing, research and development, patents and royalties.

The total expenditure required, such as initial costs, production costs incurred as well as tools and materials, will be used as a calculation when looking at the profits obtained. In general, it can be seen in Fig. 2.

Figure 2 the analysis of all conditions in the particle board production process and results. The production of sawdust into particle board at each stage and the entire process carried out is analysed in detail. Under normal production conditions, the particle board production business will be quite profitable economically. In economic evaluation, ideal conditions are needed which can be a reference and benchmark for a project. Figure 2 shows the relationship between CNPV/TIC versus time. The y-axis is CNPV/TIC and the x-axis is time (years). The graph

shows a decrease in income in years 1 to 3, this is due to the initial capital costs such as the tools needed in the educational props (APE) production process being purchased. In the 4th year, the graph shows an increase in income, this condition is PBP. Profits can cover the initial capital spent and profits continue to increase thereafter until the 20th year. Thus, the production of materials that make up science teaching aids "fortable boards" can be considered a profitable project because this project requires a short time to recover investment costs because the PBP is only around 3 years. This project is ideal for implementation in industrial production. The results of the PBP analysis reveal that the point where the return on capital is less than the planned project life is said to be profitable for producers. This business can be a recommendation for anyone who is interested in producing it. Finally, this study adds new information as reported elsewhere [18-21].

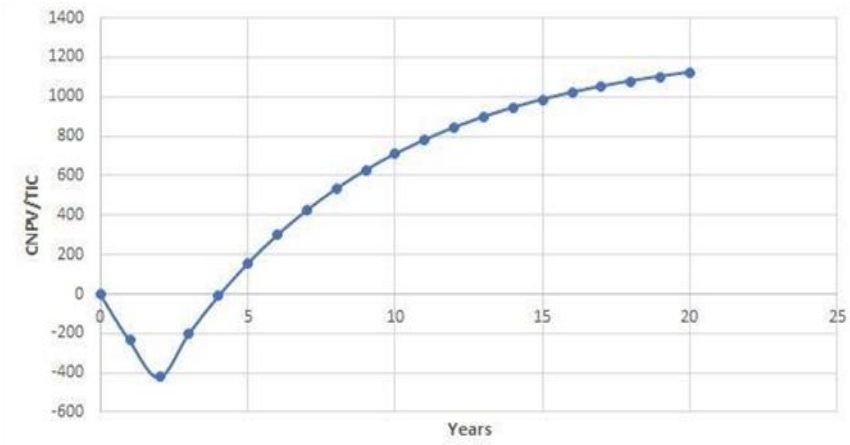

Fig. 2. CNPV/TIC with various economic evaluation parameters in the ideal condition.

5. Conclusion

Based on the economic analysis carried out, making particle board from rubber wood can be profitable. From an economic perspective, it can be seen that the profits obtained in less than 5 years have been able to recover all production costs incurred at the beginning. Apart from that, the use of sawdust can minimize unproductive paper waste and can be used sustainably to make high-quality science learning media. This is also a solution to the problem of waste and environmental pollution. Particle board also provides benefits in the world of education where it can later be used as material for making science learning media on an on-going basis.

Acknowledgments

We acknowledged Chancellor of Universitas Djuanda.

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