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Mechanical Properties of Particle board from Empty Palm Fruit with Polyester Resin Adhesive

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ABSTRACT

The need for particleboard in Indonesia is increasing every year. Particleboard is usually made of wood that comes from the forest so it has a bad effect and forest products will decrease over time. To overcome this problem, new knowledge is created that can be done. The new knowledge is like utilizing empty palm oil bunches for particle board material to replace wood raw materials. Particleboard is usually made of wood or other lignocellulosic materials such as oil palm empty bunches. The empty fruit bunches that have been made will be mixed with polyester resin as an adhesive. This study examines the effect of the percentage of polyester resin adhesive used, namely 90%, 75% and 60%. The process of making particle board starts with the preparation of raw materials such as palm empty fruit bunches and polyester resin. For empty bunches fiber used is 1 cm long. After the particle board is made, a hardness test is carried out using a durometer with the ASTM D2240 standard.

INTRODUCTION

The development of the palm oil industry in Indonesia has resulted in more and more waste produced by palm oil processing, both from liquid waste and solid waste. Waste treatment is a problem for palm oil processing factories. Palm oil liquid waste will be processed and can be disposed of to the environment if it has been processed and meets the standards, for solid waste itself one of them is empty palm oil bunches [1-3]. Indonesia has a very large potential for waste of Oil Palm Empty Fruit Bunches (TKKS). According to Wahyuni (2008), a palm oil mill (PKS) with a processing capacity of 30 tons of Fresh Fruit Bunches (FFB)/hour and an average operation of 20 hours/day will produce 120 tons of Empty Palm Oil Bunches (TKKS) every day. According to Isroi (2008), the waste of Oil Palm Empty Fruit Bunches (TKKS) can reach 220 kg from every tonne of FFB processed. In 2009, it is estimated that the potential for OPEFB waste can reach more than 2 million tons [4-5].

Empty oil palm fruit bunches

Oil palm empty fruit bunches are one of the solid wastes produced from processing palm oil into crude palm oil (CPO) or palm kernel oil (PKO). Oil palm empty fruit bunches are the largest waste produced by oil palm plantations. The number of empty fruit bunches reaches 30-35% of the weight of fresh fruit bunches each harvest. Mature oil palm plants will produce oil palm empty fruit bunches of 6 tons/ha/year [6]. However, until now, the utilization of oil palm empty fruit bunches has not been used optimally [7].

A. Components of oil palm empty fruit bunches

The largest components in oil palm empty fruit bunches are cellulose, hemicellulose, and lignin. Physically, oil palm empty fruit bunches consist of various kinds of fibers with compositions such as

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approx. cellulose (45.95%), hemicellulose approx. (16.49%), and lignin approx. (22.84%). So that the empty fruit bunches of oil palm are one of the sources of raw materials that can be used for the manufacture of particle board [8-9].

1. Cellulose

Cellulose is the main component of plant cell walls. Cellulose is a polymer in the form of linear chains linked by -1,4 glycosidic bonds. The linear structure causes cellulose to be crystalline and insoluble. Cellulose is insoluble in cold water, hot water, neutral organic solvents such as benzene, ether, CHCL3, CCL4 etc. Cellulose is almost insoluble in dilute acids or alkalis. Cellulose is soluble in H2SO4 72-75%, HCL 45%, H2PO4 85%, cupra ammonium hydroxide, cupri ethylene diamine [10]. Cellulose is not easily degraded chemically or mechanically. In nature, cellulose is usually associated with other polysaccharides such as hemicellulose or lignin to form the main framework of plant cell walls [11].

2. Hemicellulose

Hemicellulose is a heterogeneous group of polysaccharides with low molecular weight. Hemicellulose is relatively easy to hydrolyze with acid into monomers containing glucose, monose, galactose, xylose and arabinose. Hemicellulose binds to sheets of cellulose fiber to form micrifibil which increase the stability of the cell wall. Hemicellulose is also cross-linked with lignin to form a complex network and provide a strong structure [12].

3. Lignin

Lignin is one of the components in wood; it is a three-dimensional polymer compound consisting of phenir propane units bound by COC and CC bonds. Lignin is generally resistant to hydrolysis; this is due to the presence of arylakil bonds (CC) from ester bonds [13].

Particle Board

Particleboard is made from small pieces of wood or from other lignocellulosic materials [14]. Therefore, oil palm empty fruit bunches are suitable to be used as particle board. Utilization of waste oil palm empty fruit bunches for particle board in addition to producing products that have economic value also helps overcome the waste problem in the palm oil industry [15].

According to [16], Oil palm empty fruit bunches for various particle board products are the compatibility between the adhesive and fiber at the time of product manufacture and the emergence of an unpleasant odor from the material after storage for some time. Composite material technology is currently experiencing developments for the use of natural materials as its constituent components, especially the use of natural fibers as a substitute for synthetic fibers that have been used so far. One of the reasons is because of the pollution caused by synthetic materials which are generally difficult to recycle. And also natural fibers have abundant availability and are generally environmentally friendly because they are biodegradable [17].

The use of particle board from EFB is more suitable for furniture than for building materials because of its durability usually added preservatives which amount to about 0.5 percent of the weight of particleboard. Particleboard from TKS fiber mixed with adhesive is then processed, where the size and density of the board can be adjusted according to its purpose and use [18]. The need for particleboard continues to increase. Each month a furniture factory requires at least 3,000 m3 of particleboard, most of which is imported from China and Italy due to the lack of local supply.

Polyester Resin Adhesive

Unsaturated polyester resin (UPR) is one type of thermoset which is more often referred to as polyester. Polyester is a liquid resin that has a fairly low viscosity and can dry at room temperature when mixed with a catalyst. Polyether in industry is used for several needs such as reinforcing tires, ropes, seat belts, making bottles, films. For thermosetting polyester resins, it is also used as a casting material, fiberglass coating, car body putty which is non-metallic, not infrequently polyester is also widely used for finishing on high-quality wood products such as guitars, pianos, and the inside of yachts [19].

Catalyst

The catalyst here is used to assist in the drying process of the resin; in the process of mixing the resin with the catalyst it must be completely homogeneous and not excessive. If there is an excess of the catalyst in the resin, it will produce a brittle or flammable material. For the addition of a good percentage is 1% of the volume of resin used [20].

Hardness test with a durometer

Hardness is the ability of a material to withstand the process of friction (abrasion) or pressure into (indentation) of a material itself by another hard object. The hardness test is done by pressing the hard object into the material to be tested as a measure of the hardness of the material [21].This hardness test uses a durometer test tool.

Empty oil palm fruit bunches can be used as fertilizer/compost, empty bunches can also be used to make bioethanol [22]. Not infrequently also burned in an incinerator, causing pollution to the environment. Therefore, oil palm empty fruit bunches are used in order to have more economic value, one of the uses is to make particle board. Oil palm empty fruit bunches are lignocellulosic parts so they can be used to manufacture particleboard. Particle board is a composite board that has been widely developed and is quite efficient in the use of raw materials. Particle board is a board made from small pieces of wood (wood waste) or other lignocellulosic materials including empty palm oil bunches [23-24]. The manufacture of particle board in this study used the heating method, namely by boiling the empty palm oil bunches for 2 hours and soaking the empty palm oil bunches in cold water for 24 hours. Boiling and soaking is done to reduce the extractive content in Oil Palm Empty Fruit Bunches.

The purpose of this study was to utilize oil palm empty fruit bunches into particle board and to compare the resulting product with the difference in the percentage of urea formaldehyde resin adhesive used.

EXPERIMENTAL METHOD

The explanation of the research stages of particle board manufacturing are:

A. Mold making stages
1. The material used is an iron plate with a size of 2 mm.
2. The iron plate is cut as much as 1 piece with a size of 20 cm square and 2 cm long.
3. Then the sides of the mold are welded.

B. Stages of making particleboard
1. Samples of oil palm empty fruit bunches were chopped using a machete
2. Empty bunches samples were ground using a mortar
3. Empty bunches samples were cut to get 1 cm of fiber.
4. Mixing of particles with polyester resin adhesive with a ratio of 90%, 75% and 60%.
5. Homogeneous mixture is inserted into the mold
6. The particle board is left for a few days and aerated to dry
7. The particleboard is removed from the mold with the help of a lever.

C. hardness test using Durometer
1. Particle board with a size of 20x20x2 cm was divided into 16 points for testing.
2. Tested using a shore D durometer at each point of the board that has been marked
3. Durometer testing is assisted by using a tire patch press to obtain a constant value.
4. Testing was carried out for all boards with percentages of 90%, 75%, and 60%.

RESULTS AND DISCUSSION

The results of this study include the effect of differences in the percentage of polyester resin used with the quality of the resulting board. The test used is a hardness test using a shore D durometer assisted by a tire patch press so that the hardness value you want to test is obtained. Hardness test data can be seen in **Table 1**.

Table 1. Hardness test data with shore D durometer

Resin composition	Dimensions (cm)	Test point	Hardness Durometer shore D
75%	P= 20 L= 20 T= 2	1	46
		2	44
		3	46.5
		4	46
		5	48
		6	45
		7	46
		8	45
		9	47
		10	46
		11	45
		12	46
		13	46
		14	46
		15	46
		16	46.5
		Average	45,934
60%	P= 20 L= 20 T= 2	1	21.5
		2	22
		3	22
		4	21.5
		5	21
		6	21.5
		7	22
		8	23
		9	20
		10	21

		11	21.5
		12	24
		13	21
		14	20
		15	20
		16	22
		Average	21.5
		1	60.5
		2	61
		3	61
		4	60
		5	61
		6	60.5
		7	657
	P= 20	8	59.5
	L= 20	9	62

90%	T= 2	10	62
		11	61
		12	62
		13	62.5
		14	65
		15	61
		16	64.5
		Average	61.25

Based on the data above, the hardness value of the board can be analyzed using simple linear regression. The following example is a calculation of a simple linear regression analysis.

X= resin percentage

Y= hardness value

* calculate x2, y2 and xy.

Table 2. Simple linear regression analysis

No	**Resin percentage (x)**	**Average hardness value (y)**	**x2**	**y2**	**xy**
1.	90	61.25	8100	3751.56	5512.5
2.	75	45.93	5625	2109.5649	3444.75
3.	60	21.5	3600	462.25	1290
Total	222	128.68	17325	6323,3774	10247.25

$$a=\frac{(\Sigma y)(\Sigma X2)-(\Sigma x)(\Sigma xy)}{n(\Sigma X2)-(\Sigma x)2}=\frac{(128,68)(17325)-(225)(10247,25)}{3(17325)-(50625)}$$

$$= = -56.48\frac{-76250,25}{1350}$$

$$b=\frac{n(\Sigma xy)-(\Sigma x)(\Sigma y)}{n(\Sigma X2)-(\Sigma x)2}$$

$$=\frac{3(10247,25)-(225)(128,68)}{3(17325)-(50625)}$$

$$= = 1.324\frac{1788,17}{1350}$$

*If the predicted value of the hardness of the board with a percentage other than the study sample is 50%

*regression equation y= a+bx

Then, y = -56.48 + 1.324 (50) = 9.72

So, the hard value on the board with 50% resin percentage tested using a shore D durometer is 9.72. Table 2 shows the roughness value by regression analysis.

Table 3. Testing Data for Durometer Shore D Hardness Values & Simple Regression Analysis

No	**Resin percentage**	**Hardness value**
1	50%	9.72
2	60%	21.5
3	75%	45.93
4	90%	61.26

Based on the results of the hardness test for the percentage of resin and the results of the analysis using simple regression, it can be depicted in graph 1.

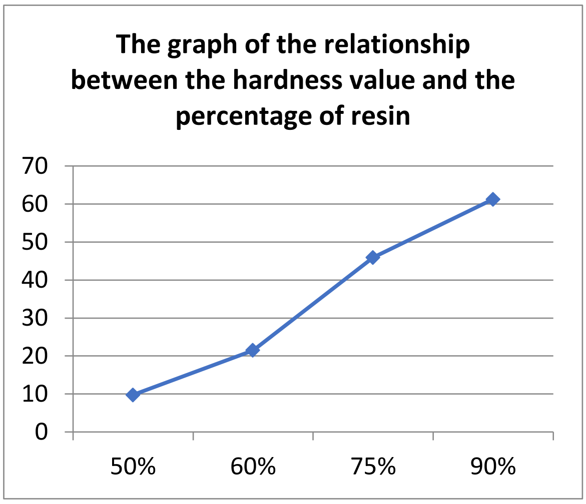

Figure 1. Graph of Relationship Between Hardness Value and Resin Percentage.

For the particleboard that has been made, it produces different density values. The following is a calculation for particleboard density for percentages of 90%, 75%, 60%.

With:

B is weight (grams)

I is the content (cm3) = length x width x thickness

Density (g/cm3) $=\frac{B}{I}$

For boards with a percentage of 90% adhesive are:

Density : = 1.044 gram/cm3 $\frac{764\ gram}{19,8\ cm\ x\ 19,7\ cm\ x\ 1,875\ cm}$

For boards with 75% adhesive percentage is:

Density : = 0.958 gram/cm3 $\frac{602\ gram}{19,8\ cm\ x\ 19,7\ cm\ x\ 1,61\ cm}$

For boards with 60% adhesive percentage is:

Density : = 0, 785 gram/cm3 $\frac{644\ gram}{20\ cm\ x\ 19.8\ cm\ x\ 2,07cm}$

Table 4. Data from the Calculation of Density Values on the Board

No	Adhesive percentage	Weight (grams)	Long, wide, thick (cm)	Density value
1	60%	644	Length : 20 Width: 19.8 Thickness : 2.07	0.785
2	75%	602	Length : 19.8 Width : 19.7 Thickness : 1.61	0.958
3	90%	764	Length : 19.8 Width : 19.7 Thickness : 1.875	1.044

Based on the results of the calculation of the density value on the board, it can be described in graph 2 below.

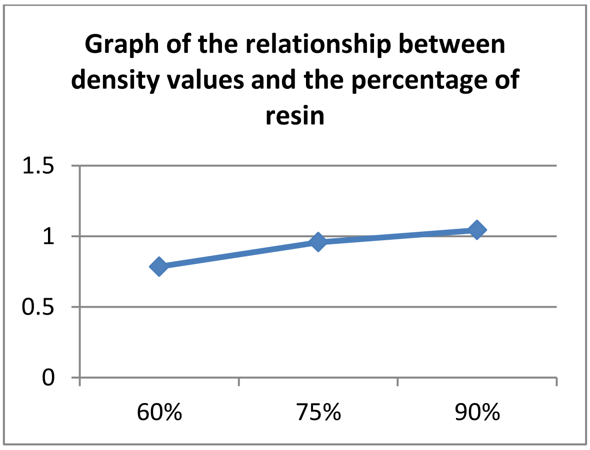

Figure 2. Graph of Relationship Between Density Value and Resin Percentage.

From the explanation of the data above, the hardness values obtained based on the shore D durometer test are (61.25), (45.93), and (21.5). And the results of the regression analysis obtained a value (9.72). And for the density value on the board obtained from the calculation, namely (0.785), (0.958), and (1.044). The hardness value obtained on particle board with 60% adhesive percentage is 21.5 H shore D . This hardness value is the lowest value in this study because the adhesive is difficult to homogenize and there is still a lot of space between the empty bunches of fiber which causes the adhesive to not bind the palm oil empty bunches evenly. And the density value on the board with 60% resin percentage is 0.785 g/cm3 . this density value is the lowest value in this study. One of the reasons is that there is no compression process when making the boards, so there is still a lot of space and cavities in the boards.

Figure 3. Particleboard test of 60% adhesive percentage with durometer

Figure 4. Particleboard weighing 60% adhesive percentage

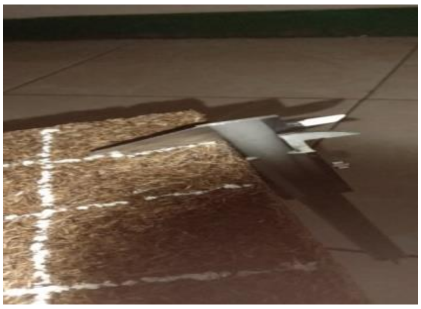

Figure 5. Measuring the thickness of the board Using a caliper on the board percentage 60%

As for the hardness value of particle board with an adhesive percentage of 75%, which is 45.93 H shore D. This value has increased because the mixing between the adhesive and the fiber of the empty bunches is not too difficult but there are still many voids and spaces on the board so that the adhesive is still not optimal. binding the fiber of empty palm oil bunches. And the density value on the board with 75% resin percentage is 0.958 g/cm3 . This density value has increased, but if the compression process is carried out, the density value obtained will be maximized because there is still ronnga on the board with an adhesive percentage of 75%.

Figure 6. Particleboard test of 75% adhesive percentage with durometer

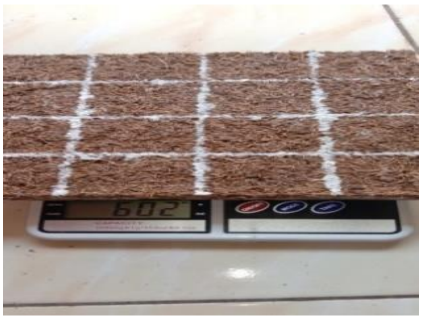

Figure 7. Weighing of particleboard adhesive percentage 75%

Figure 8. Measuring the thickness of the board Using a caliper on the board 75% percentage

Then for the value of particle board hardness with 90% adhesive percentage is 61.25%. This value is quite high because mixing the adhesive with the fiber is quite easy so that it becomes homogeneous, the adhesive is quite good at binding the fibers of the empty palm oil bunches so that the hardness value on the board is quite high. And the density value on the board with 60% resin percentage is 1.044 g/cm3 . This density value is the highest value in this study because of the large percentage of adhesive, the fiber is bound to the maximum, but if the compression process is used, the density value will be even more maximal.

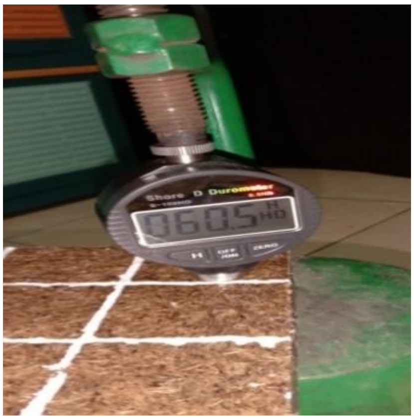

Figure 9. Particle board test of 90% adhesive percentage with durometer

Figure 10. Weighing particleboard adhesive percentage 90%

Figure 11. Measuring the thickness of the board using a caliper on the board with a percentage of 90%

CONCLUSION

The conclusions obtained in this study are as follows:

a. Coconut Kawit Empty Fruit Bunches have the potential to be used as raw material in the manufacture of particle board by mixing it with polyester resin as the adhesive used.
b. The quality of the resulting board is quite good according to the hardness test carried out, but there are still many spaces or cavities on the board because there is no compression process so that the density value is still low.
c. From the results of the hardness test, there are differences in the results of the hardness values obtained, namely (61.25), (45.93), and (21.5). The highest hardness value is for the percentage of 90% board adhesive and the smallest is the percentage of 60%. The calculated board density values are (0.785), (0.958), and (1.044). The lowest density value is on the board with a percentage of 60% adhesive and the highest density value is on the board with a percentage of 90%.

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