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Utilization Fibers and Palm Kernel Shells and Tapioca Adhesive as Matrix in the Manufacture of Composite Boards as an Alternative Raw Material in Furniture Industry

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Abstract: The objective of this was to utilization researched palm kernel shell from the matrix using tapioca glue as an alternative raw materials in manufactured of composite boards. This researched to knew characteristic of influence matrix and filler composition percentage in physics and mechanics of composite board. Physics characteristic of a composite such as the density, water content, water absorption and thickness swelling whereas the characteristic of mechanic was compressive strength test. The composition of the matrix and filler roomates used was 50%: 50%; 40%: 60% and 30%: 70% and compression at 5 MPa of pressure. The highest density was shown 0.844 g / cm ^{3} in the mixture of composition 30% matrix and filler 70%. The Lowest water content was shown 12.14% in the mixture of composition 30% and 70% filler matrix. The Lowest water absorption for 2 hours water immersion was 6.74% in the mixture of composition 30% and 50% filler matrix whereas the water immersion for 24 hours was shown 47.2% in the composition of 30% and 70% filler. The thickness swelling for 2 hours water immersion Obtained result the Lowest 18% in the omposition 30% and 50% filler matrix whereas immersion for 24 hours was shown 121% in the composition of 30% and 70% filler. The highest compressive strength for palm kernel shell composite at 0.707 MPa was shown in the matrix composition of 30% and 70% filler. The density and water content were have had complies with the requirements of JIS A 5908-1994 for particle boards.
Keywords: composite, palm kernel shells, tapioca glue, physics and mechanic characteristics.

Introduction

Increased oil palm growing areas as well as in South Kalimantan alone has the potential development of oil palm plantations up to 580 thousand hectares and which have been used for oil palm plantations in 2012 covering an area of 296 thousand hectares and is expected to continue to increase in subsequent years as well as the production of CPO the greater will be directly proportional to the amount of solid waste produced as fibers and palm kernel shells is still not fully utilized and much wasted. Therefore we need a technology in the utilization ie as reinforcement in engineering technology composite materialsthat combined with tapioca as the adhesive.

Composite board is a material that composed of a mixture or combination of two or more major elements of different macro or in the form and material composition that basically cannot be separated[1] . The advantages composite board compared to metal is resistance to corrosion or environmental influences freely and for certain types of composites have high strength and stiffness as well as better utilization of waste is wasted as the use of natural fibers.

Composite technology is a process that is relatively inexpensive and has a high economic value because it uses natural ingredients that are abundant in everyday life, especially the use of natural fibers and particles as reinforcement (filler) composite. The fundamental advantage possessed a natural amplifier is abundant in number, have a lowspecific cost, renewable and recyclable and does not pollute the environment. With the abundance of waste fibers and palm kernel shells researchers want utilization fibers and palm kernel shells as an alternative reinforcing material (filler) Glue matrix composites with Tapioca. In this research used two (2) technique of making composites are fiber composites and composite particles.

Natural Fiber Composites

Natural fibers have a strength ranging from 220 MPa (palm fruit fiber) to 1500 MPa (fiber flax) and Young's modulus between 6 GPa (palm fruit fiber) up to 80 GPa (flax), as well as its density ranges from 1.25 g/cm^3 up to 1.5 g/cm^3. While the E-type glass fibers have strength and Young's modulus of 2200 MPa 73 GPa, and a density of 2.55 g/cm^3, so to some natural fibers such as flax, hemp, jute and sisal have specific modulus competitive with glass fiber[2].

Composite material is a merger of two or more, which is formed on a macroscopic scale and physically fused to acquire new properties that are not owned by the constituent material[3]. In the merger between the fiber and resin, fiber will serve as an reinforce (filler) which usually have high strength and stiffness, while the resin serves as the adhesive or matrix to maintain the position of the fiber, transmits shear forces and also functions as a coating fibers.

Predominantly fiber will determine the strength and stiffness of the composite. The smaller the size of the fiber, it will provide adhesion and strength is getting better, because the ratio between the surface and the greater the volume of fiber[4]. The mechanical properties of the composite is strongly influenced by the orientation of the fibers, the composite can be quasi-isotropic when used short fibers randomly oriented, anisotropic when used long fibers are oriented in multiple directions, or orthotropic when used long fibers that are oriented primarily in the direction perpendicular[5].

Classification Based on the Form of Structure Component Composites

A. Fibrous Composites

Naturally, the long fibers has more power than the fibers in the form of bulk is a kind of composite which consists of only one lamina or one layer to use an amplifier in the form of fiber/fiber (glass fibers, carbon fibers, aramid fibers/polyaramide etc). Fibers are arranged randomly or with a certain orientation can even also in a more complex form such as woven.

Some types of composites can be divided into several sections[6], as shown in Figure 1

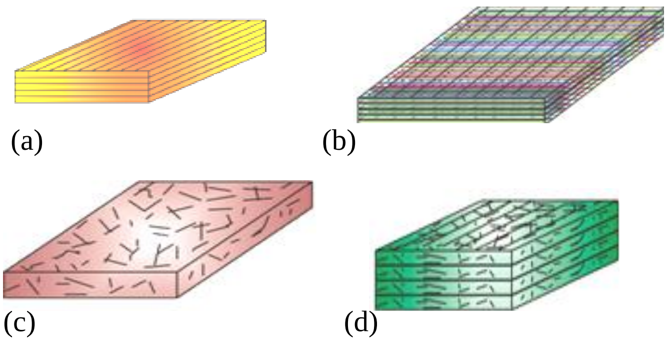

Figure 1. Type of fiber composites (a) continuous fiber composite (b) Woven fiber Composite (c)discontinuous Fiber Composite (d) Hybrid composite

The need for the placement of fiber and different fiber direction in Figure 1 to make fiber-reinforced composite differentiated into several sections including[7]:

a. Continuous fiber composite(composite reinforced with fibers continue)

Continuous or uni-directional, fiber arrangement has long and straight, forming lamina between the matrix. Composite type is most commonly used. This type has a weakness on the separation between the layers. This is because the strength between layers is affected by the matrix.

b. Woven fiber composite (composite reinforced with fibers woven)

The composite is not easily influenced by separation between the layers because of the composition of the fiber also binds between the layers. However, the arrangement of fibers that are not so straight prolongation result will weaken the strength and stiffness. Composite consists of matrix layer followed by a layer of woven fiber arrangement.

c. Discontinuous Fiber Composite

Composites with shorter fibers, random type commonly used in the production of large volumes due to lower manufacturing costs. Disadvantages of this type of random fiber is still below the mechanical properties of the fiber reinforcement with a straight on the same type of fiber.

d. Hybrid fiber composite

This kind of composite is a combination of the type of straight fibers with random fibers. This type is used in order to change their shortcomings properties of both types and can combine the advantages.

B. Particulate Composites

Particulate composites are composite particles using particle amplifier and distributed evenly in the matrix. Reinforcement material approximately the same dimensions, such as round flakes, beams, as well as other forms that have almost the same axis, which is often called a particle, and is made of one or more material embedded within a matrix of different materials.Form of composite particles can be shown in Figure 2[8].

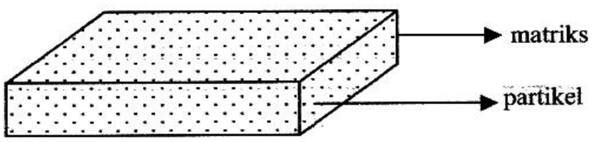

Figure 2. Particulate Composites

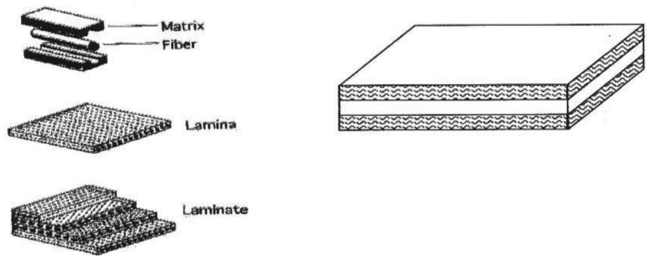

Figure 3. Laminated Composites

The particles can be metal or non-metal (Figure 2.). There are also a polymer which contains particles that are only meant to expand the volume of the material and not for the benefit as a reinforcing material[8].

C. Laminates Composites

Consisting of two or more layers are merged into one and each the layers has its own characteristic properties. This composite consists of a variety of coating material in the matrix[8], such as:

1. Bimetal is of two metal layers that have different thermal expansion coefficients. Bimetal will be curved in line with the change in temperature in accordance with the design, so it is very suitable for the type of temperature measuring devices.
2. Metal plating. Coating metal to another is done to obtain the best properties of both.
3. Coated glass. The concept is the same as the metal coating. Coated glass will be more resistant to weather.
4. Layered composite fiber. In this case the layer is formed from composite fibers and fibers arranged in various orientations. This type of composite panels used for airplane wings and fuselage.

Waste fiber and Palm Kernel Shells and Its Problems

Oil palm is a tree crop plantation stems straight from the palmae family, coming from the west coast of Africa and then spread to Indonesia. This tropical plant known as a producer of cooking oil.

Fiber and palm kernel shells are one of palm waste manufactured, percentage of fiber and palm kernel shells, respectively 13% and 5.5% of the fresh fruit bunches[9]. Fiber chemical components and palm kernel shells[10] can be seen in Table 1.

Table 1. Composition of Chemical Fibers and Palm Kernel Shells

Component	% Dry Weight	
	Fiber	Shell
Moisture	16.63	11.70
Abu levels	11.88	7.49
Volatile	56.18	64.87
Fixed Carbon	15.31	16.47
Nitrogen	0.62	1.06
Sulfur	4.35	4.77

Tapioca

Tapioca flour is flour made from manioc/cassava. Is implemented by grated, squeezed, washed, precipitated, taken sari starch, and dried. The nature of starch, when mixed with hot water will be clay/like adhesive.

Usefulness of tapioca starch, among others as an adjuvant in various industries. Compared with corn flour, potatoes, and wheat or flour, tapioca flour nutrient composition is quite good, thereby reducing damage to weaving, are also used as auxiliaries white coloring.

Tapioca processed in the form of glucose syrup and destrin is needed by many industries, including the confectionery industry, canning fruits, ice cream processing, beverage and brewing industry. Tapioca is also widely used as thickeners, fillers and binders in the food industry, such as in the manufacture of puddings, soup, baby food, ice cream, sausage meat processing, pharmaceutical industry, and others.

Bonds between Material

Composite board is a combination of the different elements of this leads to the border area between the fiber and the matrix. Mixing area between the fiber and the matrix is called the interphase region (Bonding Agent), while the mixing boundary between the fiber and the matrix is called interface[11].

In the composite mixture of failure that often occurs is debonding. Debonding is the release mechanism of the bond interface between the materials making up the composite occurred when loading and peeling fibers from the matrix. This is due to the bond interface (Interfacial bonding) less between fiber and matrix is less when given compressive load, bonding fibers and matrices easily separated or experienced debonding therefore needed strong adhesion to the surface making up the composite to avoid debonding[12].

Materials and Methodology

This research a using a variation of the composition of the matrix mixture: filler are 50:50, 40:60 and 30:60. Comparison starches : Water is 1: 1.

The Research

a. Preparation of staple fibers and particles of palm kernel shells.

To obtain staple fibers are ready for use as reinforcement in composites made several steps below:

1. Palm kernel fibers that have been taken, cleaned and boiled with water in a pan for 1 hour. With temperatures ± 100 ^{0}C. The temperature is kept constant. Boiling is done to facilitate decision-fiber. The fiber is cut to the size of a width of 1 mm and a length of 100 mm.
2. The fiber is washed and dried in the room air to the water content of ± 5%.
3. Palm kernel shells washed and dried to a moisture content remaining ± 5% then pulverized into particles (strands) with a size of 2.5 to 10 mm

b. Make adhesive tapioca with a ratio of Starch: Water is 1:1.

c. Staple fibers or particles of palm kernel shell had entered into a mixture of (b) and slowly stirred until a homogeneous mixture with the composition of the matrix mixture: filler is 50:50; 40:60 and 30:60.

d. The filming of specimens

1. Plates1 as installation of Filler and matrix
2. Plates 2 and 3 united on one plate contained two pen binders so it does not shift
3. Plates 3 with the punch as cover and then press at a pressure of 5 MPA for 20 minutes
4. Mold test specimens with the dimensions of 25x25x2.

Samples Testing

Sample testing conducted in this research include: density, water content, water absorption, compressive strength test and microstructure.

Results and Discussion

The density of composite board

One of the physical properties of the composite board which is very influential on other mechanical properties is density. Based on Figure 5. The test results are shown that the density of the composite board with the filler shells resulted the highest density of 0.844 g/cm^3 at 30% composition of the mixture of matrix and filler 70% and the lowest density of 0.7345 g/cm^3 in the composition of the matrix of 50% and 50% filler.

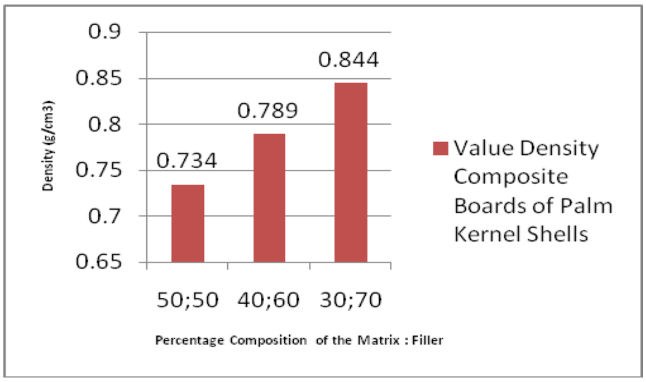

Figure 5.Graph value the density of filler composite board with the palm kernel shells

Figure 5 is shown density of the filler fiber composite boards with the palm, dihasil highest density of 0.62 g/cm^3 in the composition of the mixture of 30% matrix and 70% filler whereas the lowest density of 0.55 g/cm^3 at 50% of the matrix composition and 50% filler, This shown that the composite board with the shell filler (particles) including category meets the required standard JIS A 5908-1994 which requires the density between 0.4 g/cm^3- 0.9 g/cm^3 for a particle board, thus with the composite board with the filler fibers also meet the required density standards JIS A 5908 which requires density fiberboard ranges from 0.35 g/cm^3- 0.8 g/cm^3 andcomposite board includes medium density category.

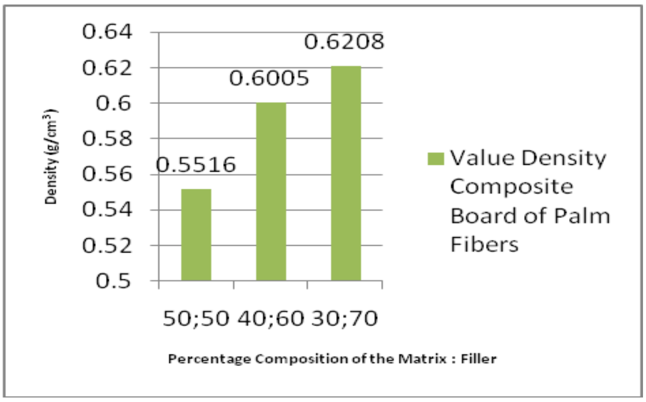

Figure 6. Graph value the density of filler composite board with the palm fibers

Figures 5 and 6 shown that the density of the palm kernel shell composite board has the highest density value if compared with the fiber composite board. This is presumably due to the lower density fiber from the shell, this contradicts that stated by Haygreen and Bowyer[13] that the value of the density of the composite board is strongly influenced by the raw materials used, the lower the density of the raw materials used the density the higher the resulting board.

Water Content

Physical properties of the water content of the composite board in equilibrium with the environment is the moisture content. From the test results, as shown in Figure 7 the lowest water content (the best) to composite board from palm kernel shells is 12.14% on the composition of the mixture of 30% matrix and 70% fillerwhereas the highest water content of 12.99% on the composition of the matrix of 50% and 50% filler. The water content of the composite board frompalm fibers as shown in Figure 6. has a low water content (that's means it is the best value for water content) of 15.378% in the composition of the mixture of 30% matrix and 70% filler whereas the highest water content of 17.673% on the composition of the matrix of 50% and 50% filler. This indicates that the composite board from palm kernel shellssatisfy the requirements JIS A 5908-1994 which requires the value of the water content of particle board was between 5% -13%. However,composite boards from palm fibers do not satisfy requisite conditions by JIS A 5905-1994[14].

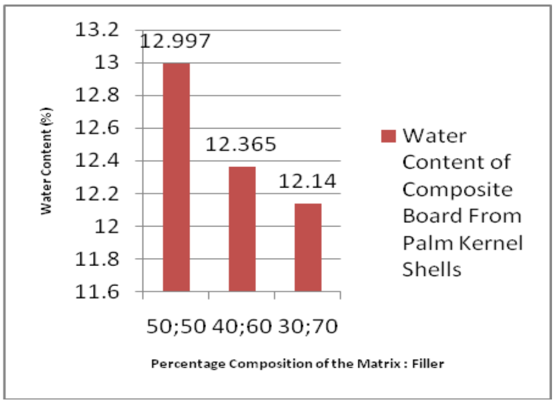

Figure 7. Graph water content of Composite boards with the filler from palm kernel Shells

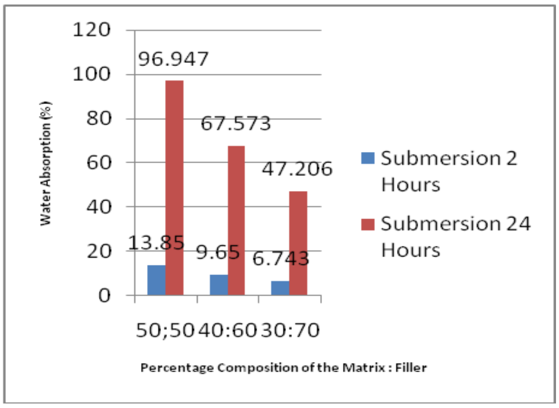

Figure 8. Graph water content of Composite boards with the filler from palm fibers

According[13] that the water content of the raw material determine the water content of the resulting composite board, the higher the moisture content of raw materials, the water content of the composite boards higher because not all of the moisture can be removed from the composite board. In the manufacture of composite board materials should be in a dry state with the water content of about 2%-5%, so if added the adhesive then the moisture content of raw materials will increase to 4%-6%. The water content of the raw materials of fibers by 8% greater than the raw material of the shell water content of 5%., The high moisture content of the composite board that mixture from palm fiber as raw material have a high hygroscopic properties compared with particles of palm kernel shells , Besides, tapioca is used as the main of adhesive component has a water content of 12% thus greatly affect the high water content of the composite board.

Water Absorption

Physical properties that involves the ability of composite board to absorb water is water absorption. Figure 9 shown that the water absorption test results on the composite board with filler from palm kernel shells with the water immersion 2 hours resulted the lowest water absorption (that's means it is the best value for water absorption) that is 6.74% on the composition 30% of the mixtureand 50% filler whereas the highest water absorption is 13, 84% on the composition of the matrix of 50% and 50% filler, while submersion in the water for 24 hours resulted the lowest water absorption (that's means it is the best value for water absorption) 47.2% in the composition of the mixture of 30% and 70% filler but the highest water absorption 96.94% in composition of 50% matrix and 50% filler.

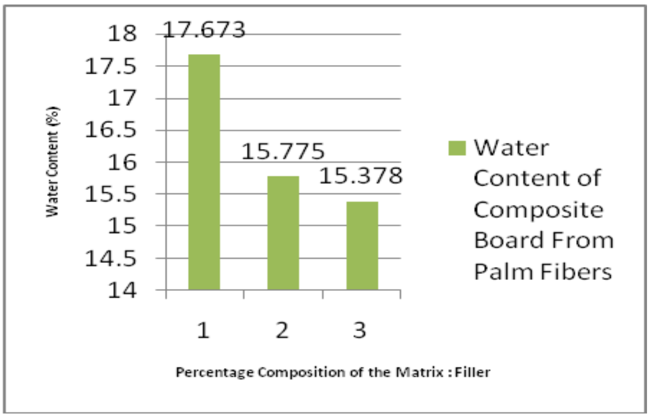

Figure 9. Graph ofwater absorption composite board from palm kernel shells

Water absorption in the fiber composite boards for 2 hours immersion can be seen in Figure 10. In this immersion produces the lowest water absorption (that's means it is the best value for water absorption) 16.3% in the composition of 30% matrix and 70% filler matrix whereas the highest water absorption 26.303% on the composition of 50% matrix and 50% filler, while submersion water for 24 hours resulted in the lowest water absorption (that's means it is the best value for water absorption) 114% on the composition of 30% matrix and 70% filler whereas the highest water absorption 114% on the composition of the matrix of 50% and 50% filler.

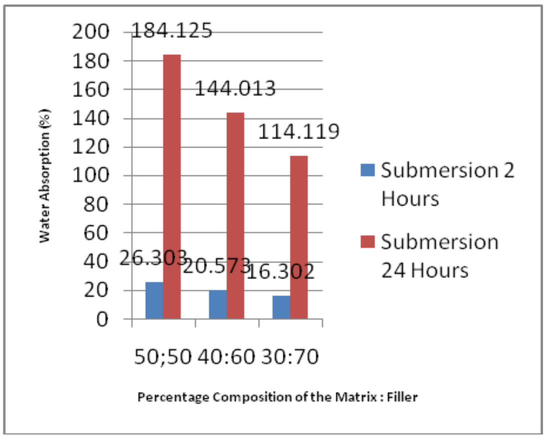

Figure 10. Graph ofwater absorption composite board from palm fibers

Figure 9 and Figure 10 shown that the high average value of water absorption of composite boards from kernel shells and composite boards from palm fibers produced in the submersion2 hours and 24 hours. On board the composite fibers have a water absorption value is higher than the particle board composite from palm kernel shell, this is due to fibers having a lower density than the palm kernel shell where palm fibers have a larger cell cavity so easily absorb large amounts of water. Water absorption 2 hours and 24 hours to have the same tendency immersion pattern, use tapioca starch matrix affect the high water absorption composite board where the resulting bond is not waterproof so the water is easy to damage the bonds between matrix and filler, the data in Figure 9 and Figure 10 illustrates the diminishing percentage of the matrix if the water absorption lower (better). JIS A 5908-1994 and JIS A 5905-1994 does not require water absorption in the composite board.

Thick development

Thick development determines a board can be used for exterior or interior, thick development test results of composite board from palm kernel shells for 2 hours immersion can be seen in Figure 11. Its shownthe thickdevelopment lowest value(that's means it is the best value for thick development) 18% of the composition of the mixture of 30% matrix and 70% filler whereas the thick development highest 23.5% on the composition of the mixture of 50% matrix and 50% filler, while the data for the development of a thick 24 hours immersion produces the lowest value (that's means it is the best value for thick development) 54.72% in the composition of the mixture of 30% matrix and 70% filler matrix and the development of the highest thickness 57.24% on the composition of the mixture of 50% matrix and 50% filler.

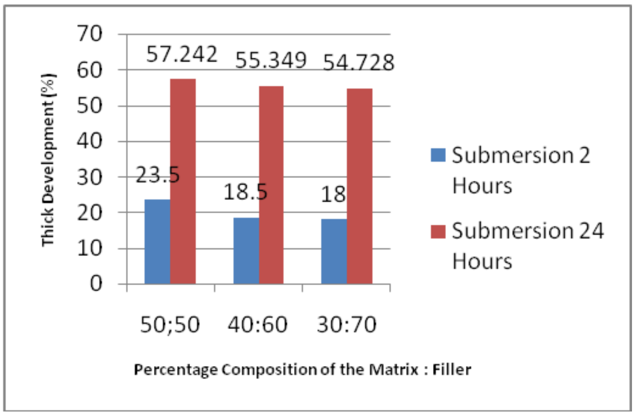

Figure 11. Graph thick development of composite board from palm kernelshells

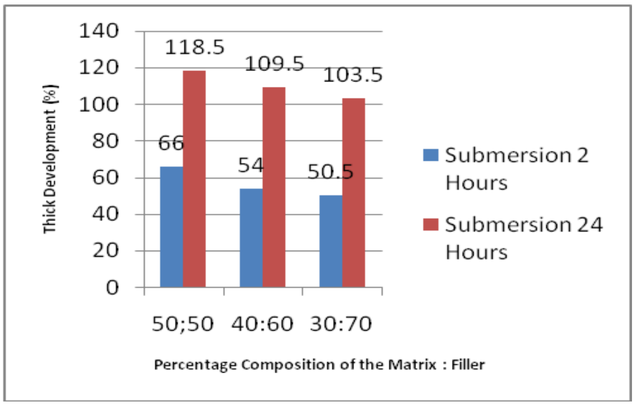

Figure 12. Graph thick development of composite board from palm fibers

Results of testing the development of thick fiber composite board shown in Figure 12, where the thick development get the lowest value (that's means it is the best value for thick development) for a 2 hour immersion was 50.5% in the composition of the mixture of 30% matrix and 70% filler whereas the highes value for thick development was 66% at 50% of the matrix composition and 50% filler, beside that the data for the development of a thick 24 hours immersion producesthe lowest of thick development (that's means it is the best value for thick development) 109.5% on the composition of the mixture of 30% matrix and 50% filler whereas the highest thick development 118.5% on the composition of 50% matrix and 50 % filler.

Figure 11 shown the overall composite board from palm kernel shell does not qualify JIS A 5908-1994[15] which requires the development of a maximum of 12% thicker. For fiber composite boards JIS A 5905-1994 does not require thick development. The high value of the development of thick composite board from palm kernel shells and composite board from palm fiber caused high absorption of water by the matrix and filler.

Compressive Strength and Microstructure Observation

Compressive strength testing aims to determine the resistance of the specimen test if subjected to a pressure. Tests conducted on composite board in dry conditions constant. Based on the test results as shown in Figure 13, the highest Compressive Strength for Composite board that reinforcement with palm kernel shells was 0.707 MPa on the composition of the mixture of 30% matrix and 70% filler and the lowest compressive strength at 0.682 MPa on the composition of 50% matrix and 50% filler. Compressive Strength for composite board that reinforcement with palm fibers as shown in Figure 14 has the highest concentration of 0.63 MPa on the composition of the mixture of 30% matrix and 70% Filler and the lowest compressive strength at 0.553 MPa on the composition 50% of the matrix and 50% filler.

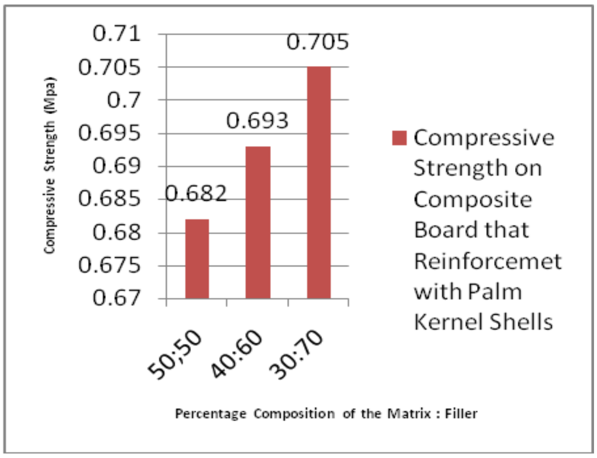

Figure 13. Value Compressive Strength Testing Board Composite Shells

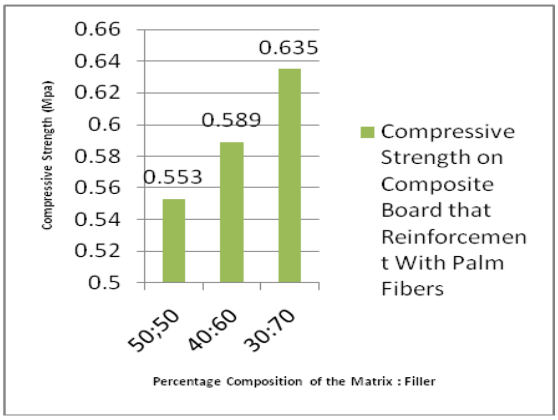

Figure 14. Value Compressive Strength Testing Fiber Composite Board

Based on Figure 13 and Figure 14 shown increased compressive strength is inversely related to the percentage of the matrix on the composite board, this is due to the mechanical properties of filler (shells and fibers) better than tapioca adhesiveas a major component, it is also due to the resulting void directly proportional to the percentage of the matrix composite board.

The surface forms of each composite board for testing press with filler palm kernel shells can be seen Figure 15 and forms the surface of each composite board for testing press with filler palm fibers can be seen Figure 16. The figure shows if the debonding and void directly proportional to the the percentage matrix, this is caused by less homogeneous mixture of tapioca starch adhesive which serves as a matrix and a less homogeneous mixture of matrix and filler during the manufacture of composite board.

Conclusion

1. Density of composite board that reinforment with palm kernel shells generated the highest density of 0.844 g/cm^3 at 30% composition of the mixture of matrix and filler 70% and the lowest density of 0.7345 g/cm^3 in the composition of the matrix of 50% and 50% filler. The density of the composite board with filler from palm fibers produced the highest density of 0.62 g/cm^3 in the composition of the mixture of 30% matrix and 70% filler whereas the lowest density of 0.55 g/cm^3 at 50% of the matrix composition and 50% filler. Composite board with palm kernel shells as the filler (particles) including category meets the required standard JIS A 5908-1994[15] which requires the density between 0.4 g/cm^3- 0.9 g/cm^3 for a particle board, thus the composite board with filler from palm fibers also meet the standards required density JIS A 5908 which requires density fiberboard range of 0.35 g/cm^3- 0.8 g/cm^3 and composite board includes medium density category.

2. The water content of the lowest (that's means the best value for water content) to board Composite with filler from palm kernel shell is 12.14% on the composition of the mixture of 30% matrix and 70% filler and the highest water content of 12.99% on the composition of 50% matrix and 50% filler. The water content of the board composite with filler from palm fibers is 15.378% in the composition of the mixture of 30% matrix and 70% filler and the highest water content of 17.673% on the composition of the matrix of 50% and 50% filler. Composite board with filler from palm kernel shells meets the requirements of JIS A 5908-1994 which requires particle board moisture content value is between 5% -13%. However, composite boards with filler from palm fibers do not meet the requisite conditions by JIS A 5905-1994[14].

3. Absorption of water on board with filler composite palm kernel shells with 2-hour water immersion produced the lowest water absorption (that's means the best value for water absorption) of 6.74% on the composition of the mixture of 30% matrix and 50% filler and the highest water absorption 13.84% on the composition of 50% matrix and 50% filler, whereasimmersion water for 24 hours produced the lowest water absorption (that's means the best value for water absorption) 47.2% in the composition of the mixture of 30% matrix and 70% filler and the highest water absorption 96.94% on the composition of the matrix of 50% and 50% filler. For water absorption in the composite boards with filler from palm fibers for 2 hours immersion produces the lowest water absorption (that's means the best value for water absorption) 16.3% in the composition of the mixture of 30% matrix and 70% filler and the highest water absorption 26.303% on the composition of the matrix of 50% and 50% filler , whereasimmersion water for 24 hours to produce water absorption the lowest value (that's means the best value for water absorption) is 114% on the composition of the mixture of 30% matrix and 70% filler and the highest water absorption 114% on the composition of the matrix of 50% and 50% filler. JIS A 5908-1994[15] and JIS A 5905-1994[14] does not require water absorption in the composite board.

4. Thick development for composite board with filler from palm kernel shells for 2 hours immersion obtained the lowest results (that's means the best value for thick development) 18% of the composition of the mixture of 30% matrix and 50% filler and the development of the highest thickness 23.5% on the composition of the matrix of 50% and 50% filler, for a 24hours immersion resultsthe lowest thick development (that's means the best value for thick development) 54.72% in the composition of the mixture of 30% matrix and 70% filler and the development of the highest 57.24% thicker on the composition of the matrix of 50% and 50% filler. development of thick fiber composite boards lowest (that's means the best value for thick development) for a 2 hour immersion was 50.5% in the composition of the mixture of 30% matrix and 70% filler and the development of the highest 66% thicker on the composition of the matrix of 50% and 50% filler, while the data for the thick development 24hours immersion results thick development lowest (that's means the best value for thick development) 109.5% on the composition of the mixture of 30% matrix and 50% filler and the highest thick development 118.5% on the composition of the matrix of 50% and 50% filler. Overall shell composite boards are not eligible JIS A 5908-1994 which requires the development of a maximum of 12% thicker. For fiber composite boards JIS A 5905-1994 does not require heavy development.

5. The highest Compressive Strength for composite board with filler from palm kernel shells was 0.707 MPa on the composition of the mixture of 30% matrix and 70% filler and low value at 0.682 MPa compressive strength at 50% of the matrix composition and 50% filler. Compressive Strength Composite boards from palm fibers high value at 0.63 MPa on the composition of the mixture of 30% matrix and 70% filler and low value at 0.553 MPa compressive strength at 50% of the matrix composition and 50% filler.

6. This research recommended that the shells and fibers of palm and tapioca adhesive can be used as an alternative raw material wood composite board replacement.

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