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The Influence of Steel Wool Fiber Length on The Characteristics of The Particle Board

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ABSTRACT
The use of wood powder can be reduced by a mixture of cinnamon, bamboo powder, and steel wool as a filling of the composite particle board. The length of steel wool in this study was determined by the size, i.e. 2, 4, and 6 mm. The composite composition comparison was 30% cinnamon powder, 30% bamboo Powder, 1% wool steel, 29% PVAc, and 10% epoxy resin. Compression process using the cold press single punch method for 2 hours then post curing process at a temperature of 150 ºC for 1 hour. The results of this study show that steel wool length influences the characteristics of the particle board, both physical properties, mechanical properties, and morphological structure.
Keyword: Steel wool, Composite, Partikel Board, Hardness, Flexibility

ABSTRAK
Potongan–potongan kayu dan serbuk gergaji umum digunakan dalam pembuatan komposit papan partikel. Penggunaan serbuk kayu dapat dikurangi dengan campuran serbuk kayu sengon, serbuk bambu, dan steel wool sebagai pengisi dari komposit papan partikel. Panjang steel wool pada penelitian ini ditentukan ukurannya, yaitu 2, 4 dan 6 mm. Perbandingan komposisi penyusun komposit adalah 30% serbuk sengon, 30% serbuk bambu, 1% steel wool, 29% PVAc dan 10% resin epoksi. Proses kompaksi menggunakan metode cold press single punch selama 2 jam kemudian dilakukan proses post curing pada suhu 150 oC selama 1 jam. Hasil penelitian ini menunjukkan bahwa panjang steel wool berpengaruh terhadap karakteristik papan partikel, baik sifat fisik, sifat mekanis dan struktur morfologi.
Keyword: Steel Wool, Komposit, Papan Partikel, Kekerasan, Kelenturan

1. Introduction

Furniture is one of the household accessories that includes all the items like tables, wardrobes, and chairs. The furniture itself has a function to make a home or workplace more comfortable and look elegant. Demand for furniture has increased over time as it is widely used for the needs of homes, offices, cafes, or elsewhere. Furniture made of composite materials is also designed to reduce large-scale tree cutting, which has a major impact on global warming. Therefore, at the moment, furniture is widely designed using composite material, besides being cheaper, it can also reduce unused production residues such as cinnamon, bamboo, coconut fiber, and others that are already unused.

A composite material is an engineering material from a combination of two or more materials to obtain a mixture of new and stronger material properties. A compound is a mix of one or more materials on a macroscopic scale to form a new material that is more valuable [1]. The combinations of two different materials are expected to be able to produce a higher quality material than the previous one. The final properties of composite materials will be better than those of the supporting materials.

A particle board is a board made of composite material formed from wood particles or other materials containing lignocellulose that are bound to a synthetic adhesive and then heated [2]. The advantages of a particle plate compared to its original wood are that it is free from cracks and ruptures, the density of the particleboard can also be adjusted according to needs and the advantage of a particle board has isotropic properties and is easy to work with, and can regulate its characteristics and qualities. Low dimensional stability is the board's weakness [3].

A composite board has a filler that is an important part in determining the properties of a composite material, and has a function as an amplifier of the matrix. Fillers have advantages and variable strengths that enhance stiffness and moisture strength, heat resistance, abrasion strength, and heat contraction. The research uses cottonwood and bamboo as fillers as well as steel wool fiber as reinforcements.

Albizia Chinensis is one of the most abundant types of wood in Indonesia. As of 2015, the production of cinnamon wood in Indonesia reached 2.85 million m^3. It's because this wood includes a fast-growing plant so it's grown by a lot of people, especially in Java [4].

Bamboo is one of the natural resources that is widely exploited by society because of its beneficial properties: strong, straight, flat, hard, easy to split, easily shaped, easily handled, and easy to transport. Besides, bamboo is relatively inexpensive compared to other materials as it is often found around settlements, especially in rural areas. Bamboo has become a versatile plant for most people in Indonesia [5]. Bamboo also has a pretty strong and durable structure that can replace the properties of wood.

Composite materials in some structural are used epoxy resins widely, this resin is also used as a mixed material for packaging, molding compound, and glue. Epoxide resins are very well used as the matrix on compounds with glass fiber reinforcers. On concrete, the use of epoxide resins can accelerate the hardening process, because epoxy resins generate heat that helps speed up hardening [6].

Polyvinyl acetate (PVAc) is one of the thermoplastic polymers that has been widely known as a raw material in the glue industry. PVAc, whether modified or not, in the form of emulsion or solution, as a copolymer shows a diversity that makes this glue suitable as a bonding medium of various materials in particular wood products and their derivatives [7]. According Malinda PVAc is a glue that has a uniform viscosity, does not contain toxins, has an affordable price and has no adverse effects on the environment such as odor and fungus resistance [8].

In this study, an experiment was carried out to make a composite material of a particle board that belongs to the type of Polymer Matrix Composite (PMC). The strength and elasticity values need to be known so that the results of this research can be used as an alternative to the making of particle boards.

2. Method

The ingredients in the study are bamboo powder, wood powders, steel wool fibers, polyvinyl acetate (PVAc), epoxy resin, sodium hydroxide (NaOH), and aquades.

a b c

Figure 2.1. (a) bamboo powder; (b) wood powder; (c) steel wool

The type of bamboo used is lime bamboo from the Cilegon region. Bamboo is thought to produce bamboo powder. The size of the powder used is 35 meshes. The wood used is obtained from the scraping of cinnamon wood from the area of Pandeglang which is then refined to be used to obtain a finer piece of wood of the size of 35 meshes. Polyvinyl acetate (PVAc) as the glue used is Lem Fox and the epoxy resin used is Milan Epoxy Adhesive.

The composition of the material is based on volume fractions after the rule of mixture calculations, then obtained 30% cinnamon powder, 30% bamboo powder, 29% polyvinyl acetate (PVAc), 10% epoxy resin, and 1% steel wool which have length variations of 2, 4 and 6 mm. The composition of materials is intended to obtain the mass value of each material to be used. In determining the mass, the volume of the mold and the density of the material are required. As for the density value of cinnamon wood 0.43 g/cm^3, bamboo limestone 0.60 g/cm^3, steel wool 6.61 g/cm^3 epoxy resin 1.1g/cm^3, and polyvinyl acetate (PVAc) glue 1.07 g/cm^3.

Volume of printing = length x width x height
= 21 cm x 21 cm × 1.7 cm
= 749.7 cm^3

Searching for sample material mass (V% x Printing x density):
1. Bamboo powder = 30% x 749.7 x 0.60 = 134 gram
2. Cinnamon wood powder = 30% x 749.7 x 0.43 = 96.71 gram
3. Steel wool = 1% x 749.7 x 6.6 = 49.48 gram/long variation
4. Adhesive PVAc = 29% x 749.7 x 1.07 = 232.63 gram
5. Epoxy resin = 10% x 749.7 x 1.1 = 82.47 gram

Bamboo powders are immersed in (sodium hydroxide)NaOH for 120 minutes to reduce the composing component on the fiber that is less effective in terms of interface strength and raise the level of hardness of the external field of the fiber [9]. Epoxy resins and hardeners in a 1:1 ratio are mixed periodically into the mixed composite. Flat-mixed compounds are placed in a 21 x 21 x 1.7 cm mold and then humidified.

The composite is compressed by pressing it at a pressure of 30 bars and holding it for 120 minutes. The next process is curing, that is, drying the particle board using an oven at a temperature of 150°C for 1 hour. The modulus of rupture test of a composite board is carried out using the Universal Testing Machine (UTM) machine using the ASTM D790-03 standard. The durometer test of the composite particle board refers to the ASTMA D2240-15. The size used for this hardness test has a minimum thickness of 6.25 mm.

a

b

Figure 2.2 (a) Universal Testing Machine (UTM); (b) Durometer Shore D

The density test is performed by comparing the weight and volume of the particle board. This test refers to the SNI 03-2105-2006 standard. The size used at the time of this test is 10 x 10 cm. The thickness development test was performed to determine the ability of particle boards to respond to water intake referring to SNI 03-2105-2006 standard the thick development value is a maximum of 12%. The size used for thickness development testing is 5 x 5 cm.

The water absorption test is carried out simultaneously with the thick development test and aims to analyze the moisture that occurs on the particle board. This test is done by immersing the sample in the water for 24 hours, comparing the time values before and after the immersion, and dividing by the time value before the submersion in the results of the presentation. This morphological test is done using an optical microscope to see the microstructure on the composite board.

3. Result and Discussion

Steel wool is a non-natural metal material, and can merge better when combined with the same material that is made of metal [10]. Variations in the length of steel wool fibers can influence the physics, mechanics, and morphology of the composite board particles.

3.1 Density

Density or density is a comparison of masses per unit of volume. Previous research by Lusiani [11] stated that the longer the fiber, the greater the density, even though the test results of density did not increase too far. This increase in density is due to the length of variation of each fiber so the amount of fiber will be smaller and smaller, which means that the longer the fiber, the less matrix will cover the fiber, which will result in a higher density. The highest density values occur in steel wool with a length of 6 mm, i.e. 0.662 g/cm^3 and the lowest frequency value occurs in steel wool of 2 mm length.

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Based on the graph in Figure 3.1, it can be seen that the addition of steel wool fibers makes the density of the particle board slightly increased, although not so significant as in the research carried out by Garcia, et al [10] one of the causes is because steelwool is a non-natural metal material, and can merge better when combined with the same material that is made of metal.

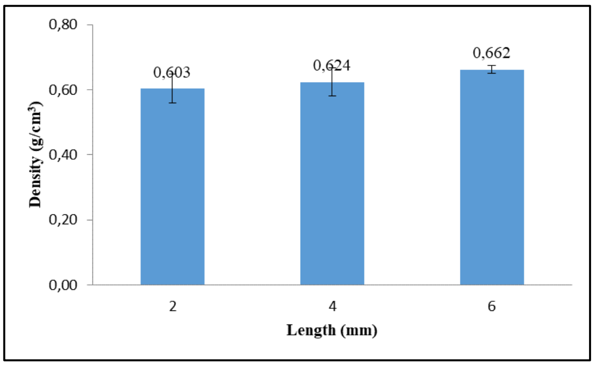


Figure 3.1 Density of Composite

In particle plate density, the standard type used is the Indonesian National Standard with specification SNI 03-2105-2006 wherein the standard sets the level of density or density on a particle board and must have density values in the range of 0.4 – 0.9 g/cm^3. So based on the test results that have been carried out and compared with the density standard used, then the three samples in the test that have already been performed all comply with the existing density Standard, which is SNI 02105-2006.

3.2 Water absorption

The water absorption test was performed to determine the ability of the particle board to absorb water. Additional lengths of steel wool can significantly affect the decrease in the water absorption value. The density value obtained decreases from the length variation of 2 mm to 6 mm, i.e. from 61.03% to 38.70% (Figure 4 a), this indicates that the closer the distance between the fillers, the less water absorbent it will experience, this is also consistent with previous research by Sunardi et al [11].

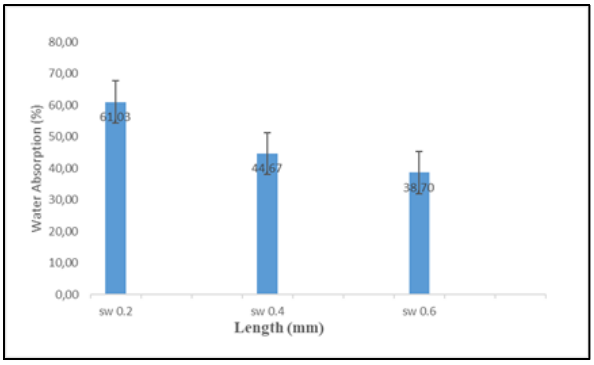


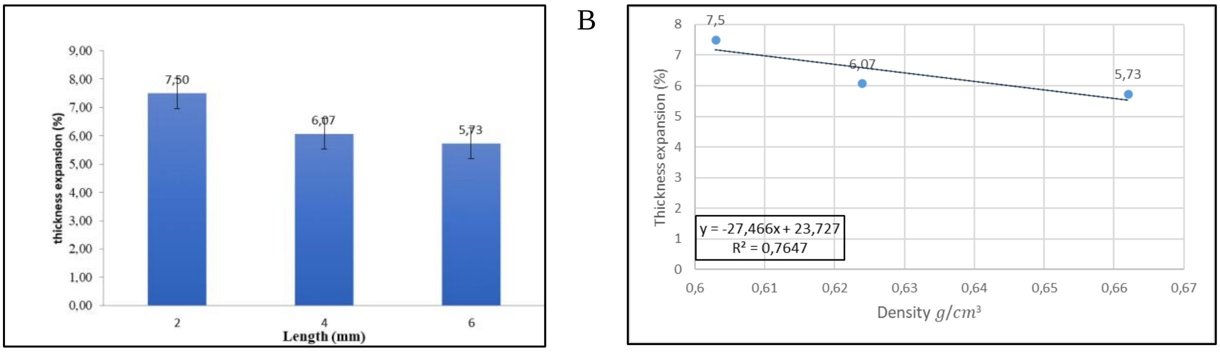
Figure 3.2 Water Absotption

In Figure 3.2 we can see that the density value is inverse to the water absorption value. So the length of the steel wool fiber has a strong influence on the water-absorption capacity, where the longer the fiber is, the smaller the value of the water.

3.3 Thickness Expansion

A thick expansion test was performed to determine the response of water entry on the particle board. The standard used in this study is SNI 03-2105-2006 with a maximum development thickness of 12%. From the thick expansion tests that have been carried out, the presentation value of thick growth decreases with the length of the steel wool. Where the result of a sample of 2 mm to 6 mm of steelwool length the resulting value decreased, i.e. from 7.50%, to 5.73%. This is compared to the reverse density value where the longer the fiber the better density is the value. This is one of the strengthening factors because theoretically density values are compared with the reversed porosity value [12].

a B



Figue 3.3 (a) Thickness Expansion; (b) Water Absorption Vs Thickness Expansion

It can be seen in the thickness development diagram above stating that the density development produced from each sample compared directly with the water absorption value that was previously tested on the sample, but the value obtained compared with the inversed density test results. The density value achieved in the previous test, experienced an increase from the particle board with a length variation of 2 mm to the particulate board with the length variation of 6 mm, this indicates that the closer the distance between the particles that become the fillers will result in water absorbtion and thicker development that is smaller and smaller this is in line with the research that has been done earlier by Sunardi, et al [11]

3.4 Hardness

One of the mechanical properties that a particle board must have is the value of the force, the force is one of the necessities in the particle plate to be able to accept a style consisting of penetration and force that is a tension and without experiencing rupture [13].

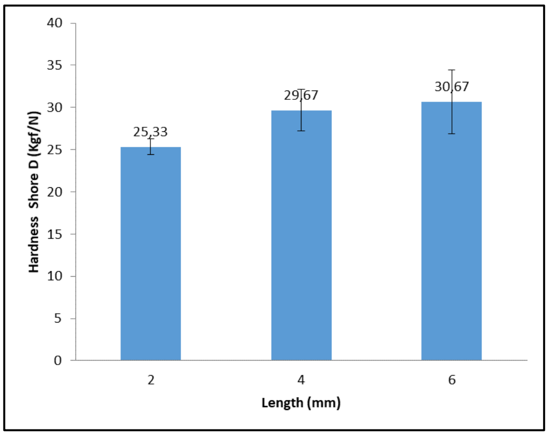


Figure 3.4 The Hardness of Durometer Shore D

Based on Figure 3.4 it can be seen that the sample with the greatest strength value Durometer Shore D is on a sample variation length of 6 mm that is to reach 30.66 Kgf/N shore D, and the smallest value is on the steel wool sample length 2 mm with a strength value of 25.33 Kgf / N shor D. This strength value is influenced by the density value, the higher the value of density will be the better the resistance value [12]. This result was reinforced by previous research that stated that the higher the density value of a particle plate, the higher it would be in direct comparison to the force value produced by the particle board [14]. It can be concluded that the length of the fiber is also influential in the strength test even though the resulting value is not significant enough.

3.5 Modulus of Rupture

The flexibility test is a mechanical test aimed at determining the maximum value of the particle board when weighing with the three-point bending method, this test is performed using the UTM (Universal Testing Machine) device and using the ASTM D 790 standard.

According to the SNI 03-2105-2006 standard where the standard value of the existing particle board is 82

Kgf/cm^2. The sample with a length variation of 2 mm obtained a sliding strength of 33.28 Kgf/cm^2, then sample 2 with a steel wool length of 4 mm obtained a slitting strength of 38.2682 Kgf/cm^2, and the last sample of 6 mm steelwool obtains a slid strength of 48.13 Kgf /cm^2.

The results of the trial on the three samples did not meet the SNI standard of the particle board. However, the case experienced an increase from the sample board variation length of 2 mm to 6 mm, this is consistent with the previous study that stated that the longer the fiber compared to the straight with the maximum value of force and the limit of elasticity, or the length of this fiber will be compared with the straight denim the value of the rigidity of the sliding [12] and the other thing that affects is the density where the previously obtained density value is compared to the straight with the sliding rigidity value. The result is also reinforced by the opinion [15] that in his research the value of sliding tightness is comparable to a straight as well as with the values of the particle plate density so that this is in line with the research that has been done.

a b

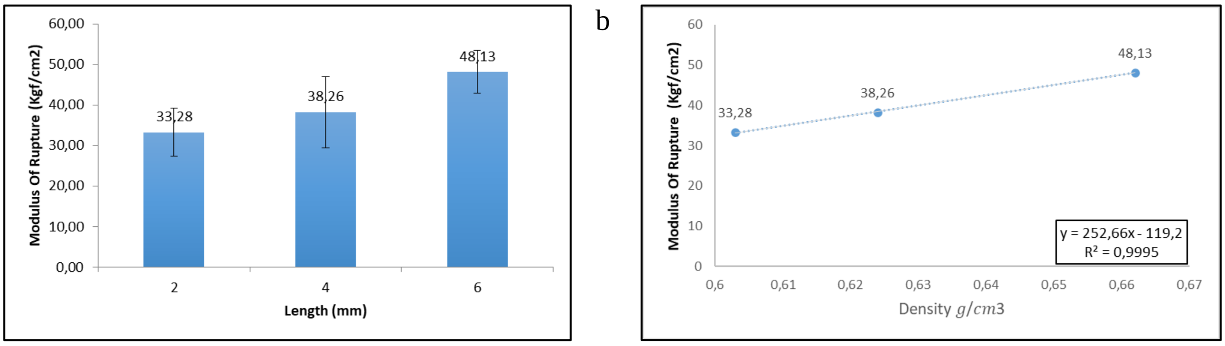


Figure 3.5 (a) Modulus of Rupture (b) Density vs Modulus of Rupture

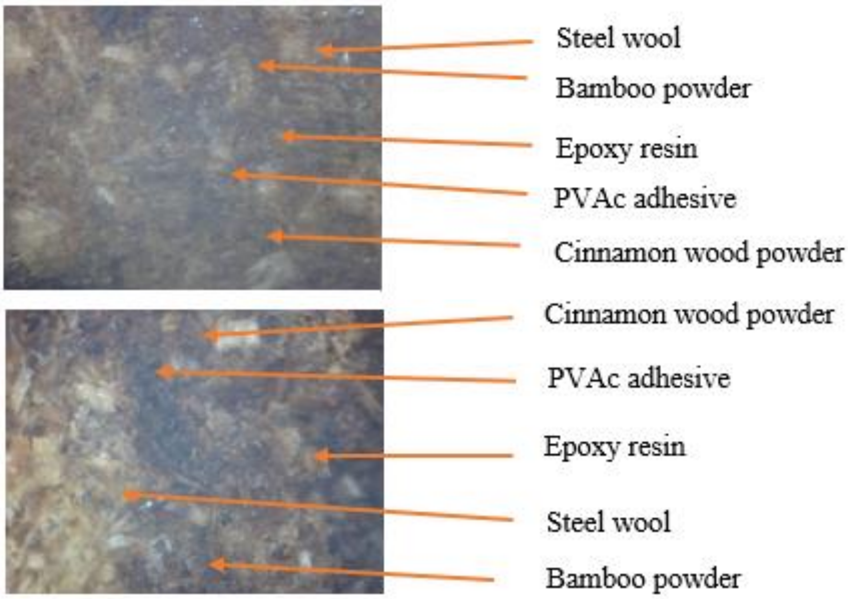
There is a correlation between the value of the Modulus of Repture (Kgf/cm^2) and the density of g/cm^3. Figure 3.5 b shows that the relationship between the Modulus of Repture and density can be said to be relatively straightforward, the higher the density value the higher the fluidity value.

3.6 Morphological Structure

The purpose of this test is to find out how the shape of the fracture and the condition of the particle after a fracture. In the observation of these micro-structures, the instrument was used as an optical microscope and enlarged 25x.

a

b



c

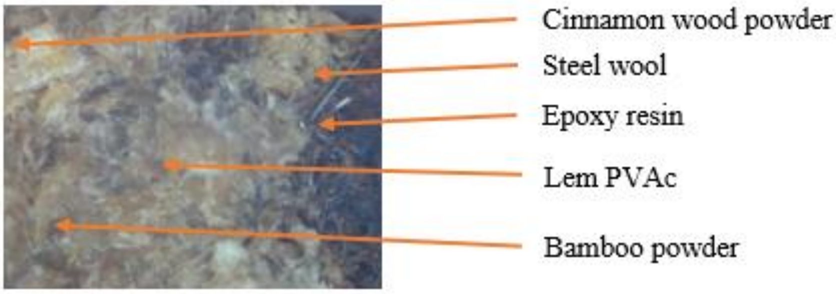


Figure 3.6 Morphological Structure (a) Steelwool of 2 mm; (b) Steelwool of 4 mm; (c) Steel Wool of 2 mm

Based on the three figures above, it can be concluded that almost all experimental samples with different length variations of steel wool fibers have holes or porosities that cause increased water absorption. Porosity occurs due to the presence of air trapped in the particle board causing porosity. Of the three variations above, a sample with a steelwool length of 2 mm has the most porosity that causes water to enter the holes, which is what causes the test value of water absorbance to be quite high.

The sample with the least porosity compared to the three samples was found on a 6 mm steel wool sample. This is consistent with the test results that have been carried out, which on a board with a length variation of 2 mm has a lower density value compared with a plate with a variance of 6 mm, it was followed by a density and flexibility test where the results of the test stated that a particle board with variation length 6 mm obtained a good result when comparing with a test board of particles with variations length 2 and 4 mm, otherwise resulting from a good test board is due to the uniform distribution of the matrix and the amplifier so that the result is good.

According to Lusiani [12], the longer the fiber, the larger the density value, although the increase in density test results is not too far. The increase in this density due to the length of variation of each fiber then the amount of fiber will be smaller, which means that if the fibre is longer then there will be less for the matrix to cover the fibers which will result in a high density.

3. Conclusion

The length variation of steel wool on a particle board affects the physical properties of the particle plate. The longer the steelwool fiber, the higher its density. This is due to the water absorption and thickness of the steel wool. The three fissile properties have met the SNI standard for composite particle boards. The variation in the length of steel wool on a particle board also affects the mechanical properties of the particleboard, the longer the steelwool fiber is, the higher its strength and sliding strength. The strength value already meets SNI standards, but the sliding force does not meet SNI's standard value. The morphological structure suggests that the longer the steelwool fiber is, the smaller the porosity.

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