Journal of Technomaterial Physics Vol. 4, No. 1, 2022 | 10 - 17

talenta PUBLISHER

JoTP
Journal of Technomaterial Physics

Effect of Mass Addition on Physical Properties and Mechanical Properties of *Agave Sisalana* Fiber Composites - Epoxy

T. Sembiring [1*] and A. S. Sinaga[2]

[1,2] *Department of Physics, Faculty of Mathematics and Natural Science, Universitas Sumatera Utara, Medan 20155, Indonesia*

Abstract. Research on the effect of the addition of *Agave Sisalana* fiber mass on physical properties and mechanical properties in sisal-epoxy fiber composites has been conducted as an alternative material for composite materials. *Agave Sisalana* fiber was taken from Sumber Agung Village of Rejo Stage District of Blitar Regency, East Java. *Agave Sisalana* fiber as a filler varies the composition of fiber mass 0 g, 2 g, 4 g, 6 g, and 8 g. The results of testing the physical and mechanical properties of *Agave Sisalana* fiber composites produce a density value of 1.064 g/cm^3 - 1.335 g/cm^3, water absorption 1.59% - 2.62%, porosity 1.7% - 3.5%, strong bending 54.542 MPa - 86.412 MPa, strong impact 29.92 kJ/m^2 – 98.32 kJ/m^2, and strong tensile 1.983 MPa – 12.368 MPa. The physical and mechanical properties testing results have met JIS A 5905:2003 Standards, namely strong bending >32 MPa, the density of 0.3-1.3 g/cm^3, and water content < 25%. *Agave Sisalana* fiber composites with epoxy resin can be applied to car bumpers.

Keyword: Composites, Epoxy Resins, Mechanical Properties, Physical Properties, *Agave Sisalana* Fibers.

Received 25 January 2022 | Revised [11 February 2022] | Accepted [25 February 2022]

1 Introduction

Currently composite technology is developing widely. This is due to the growing need for construction materials, the development of composite materials technology records various findings that are innovative, even quite amazing [1]. Composite boards promise special advantages. In addition to strength, it also has economic value and corrosion resistance. Environmentally friendly composite materials are usually based on natural fibers that can be obtained around the environment [2-4]. Composites are one alternative to produce materials whose mechanical properties are better than other materials [5].

Fiber composite consists of two, natural fiber and synthetic fiber. Natural fiber is an environmentally friendly material that is a technological demand today, so research on natural

*Corresponding author at: Jalan Bioteknologi no.1 Medan, 20155, Indonesia

E-mail address: t.sembiring@usu.ac.id

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fibers continues to be developed to reduce environmental pollution caused by industrial waste [6-7]. In the industrial field, composite materials with natural fiber reinforcements have been applied by car manufacturers as car panel reinforcement materials, rear seats, dashboards, and other interior devices [8]. Examples of natural fibers are jute, cotton, wool, silk, and hemp (hemp), while synthetic fibers are glass, carbon, rayon, and nylon [9-11].

Currently many scientists conduct research on underutilized crop resources as an alternative to the world's food resources along with the issues circulating in the community about the imperiousness of global food shortages in the next year [12]. *Agave Sisalana* is important as a superior food crop and starch-producing crop in the 21st century, as it is a sustainable crop and can grow in extreme soil conditions. Indonesia is a country that has an area of 50% of the world's *Agave Sisalana* plants and 85% of them are in Papua [13].

During this time, the research conducted a lot using fiber synthesis. This is because synthetic fibers are easy to obtain, practical, and their mechanical properties have been certain [14]. But waste fiber synthesis gives a bad environmental impact so switch to natural fiber [15-20]. Therefore, researchers are interested in knowing the effect of addition of *Agave Sisalana* fiber mass on the physical and mechanical properties of composites with *Agave Sisalana* and epoxy fiber with the hand lay-up method to obtain a strong, sturdy, flexible and lightweight composite.

2 Materials and Methods

2.1 *Agave Sisalana* Fiber Preparation

Good quality *Agave Sisalana* leaves are leaves that are high in size, taken at the base and skinned. Furthermore, the bark is cut to a size of 1 m and soaked in water for 24 hours to facilitate the decomposition of fiber, then dried using sun heat. Once dry, the fiber feeder manually uses the hands to remove the lignin content of *Agave Sisalana* leaf skin that has been cooked washed using aquadest, after which it is dried at room temperature.

2.2 Composite Manufacturing

The mass of *Agave Sisalana* fiber is weighed using a digital analytic balance sheet. Cleaned molds so that dirt does not stick to the mold. Iron plates are coated with aluminum foil for the molding base section and mold cover. Molds and iron plates are smeared with wax so that the sample does not stick when removed from the mold. The exposure resin and hardener are weighed with a ratio of 1:1 mixed and stirred evenly. *Agave Sisalana* leaf fibers are arranged on the mold then poured the epoxy mixture with herdener into the mold using a spatula. The mold is covered using an iron plate and stored indoors for 24 hours. The sample is removed from the mold slowly, then tested for its physical and mechanical properties.

3 Result and Discussion

3.1 Physical Testing

A. Composite Density

The results of the composite density testing of *Agave Sisalana* fibers can be seen in Figure 1.

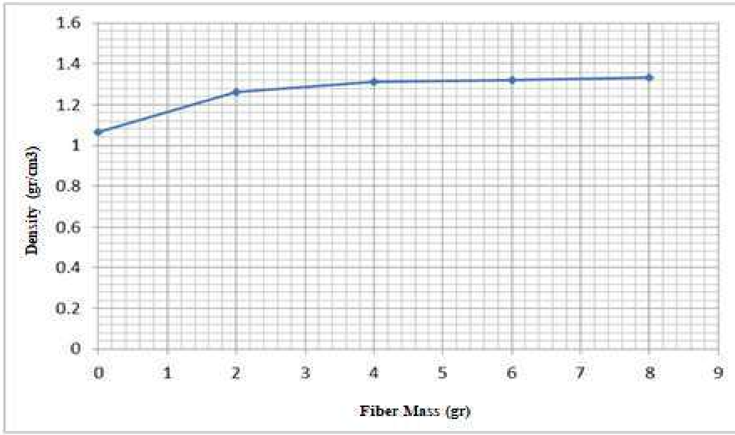

Figure 1. Graph of fiber mass with *Agave Sisalana* fiber composite density

Figure 1 shows the resulting composite density of fiber composition of 1.064 g/cm^3, fiber composition of 2 g by 1.262 g/cm^3, fiber composition of 4 g by 1.315 g/cm^3, fiber composition of 6 g by 1.320 g/cm^3 and fiber composition of 8 g by 1.335 g/cm^3. The composite density of *Agave Sisalana*-epoxy fibers has an average density of 1.31 g/cm^3. Test results showed that the addition of *Agave Sisalana*-epoxy fiber mass to composites had no effect on composite density values.

B. Porosity

The results of the *Agave Sisalana* fiber composite porosity test can be in Figure 2.

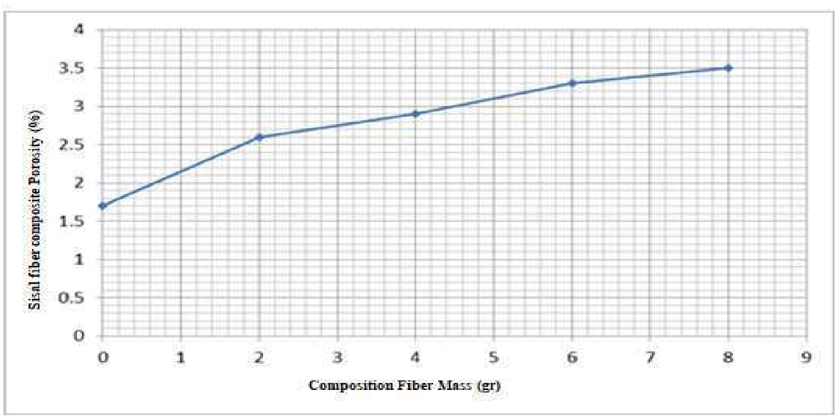

Figure 2. Graph of composition fiber mass with *Agave Sisalana* fiber composite porosity

Figure 2 shows the composite porosity produced at a 0 g fiberless composition of 1.7%, a fiber composition of 2 g by 2.6%, a fiber composition of 4 g by 2.9%, a fiber composition of 6 g by 3.3% and a fiber composition of 8 g by 3.5%. The large increase in fiber mass in composites resulted in increased composite porosity. This is because the larger the mass of the fiber in the middle causes its wetting by the liquid matrix to slow down, so that the liquid matrix begins to form a gel. As a result, the air trapped between *Agave Sisalana* fibers cannot be pressed out and form air bubbles or voids so that they are susceptible to porous occurrence.

C. Water Absorption Testing

The results of the composite air absorption test of *Agave Sisalana* fibers can be seen in Figure 3.

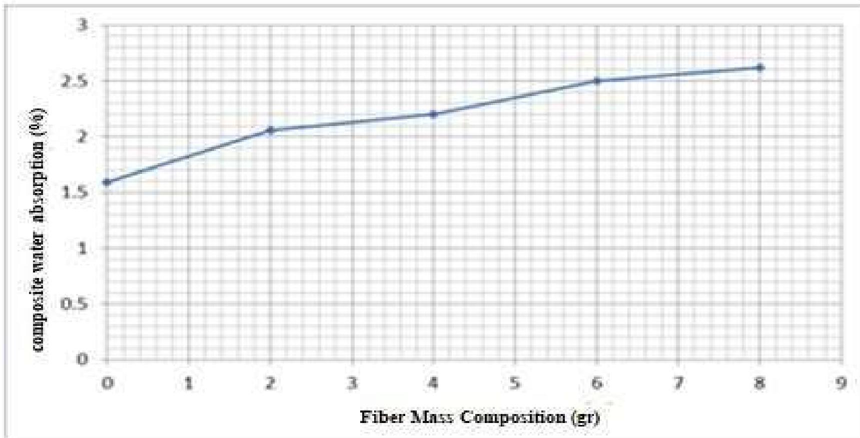

Figure 3. Graph of fiber mass composition with composite water absorption

Figure 3 shows the absorption of composite water produced at a composition without fiber by 1.59%, fiber composition of 2 g by 2.06%, fiber composition of 4 g by 2.2%, fiber composition of 6 g by 2.5% and fiber mass of 8 g by 2.62%. The relation of water absorption with the mass of *Agave Sisalana* fiber tends to increase linearly. This is because when cutting a composite sample results in the cut part having a fiber that is not covered in matrix so that a larger mass produces more cavities in the sample which makes for greater water absorption. While the smaller fiber mass has fewer cavities resulting in less water absorption.

3.2 Mechanical Testing

A. Bending Strengh Test

Sample testing is in accordance with ASTM D-790 standards. The results of a strong test of the *Agave Sisalana* fiber composite bending can be seen in Figure 4.

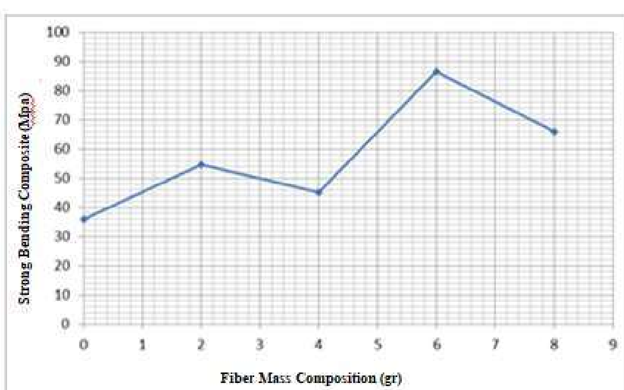

Figure 4. Graph of fiber mass composition with the strong bending composite

Figure 4 shows the strong bending composite of *Agave Sisalana*-epoxy fibers ranging from 54.542 MPa – 86.412 MPa. where strong bending is produced in the composition without fiber of 35.96 MPa, fiber composition of 2 g of 54.542 MPa, composition of fiber 4 g of 45.181 MPa, composition of fiber 6 g of 86.412 MPa and composition of fiber 8 g of 65.856 MPa. The minimum bending strength in the composition without fiber is 35.96 MPa and the maximum bending strength at 6 g fiber composition is 86.412 MPa.

The strong relationship of composite bending with perpendicular composition of fiber decreases linearly to the composition of fiber 4 g and then increases to the composition of 6 g. This suggests that the more the composition of the fiber, the smaller the composite bending. The composition of the fiber at 2 g and the composition of the 6 g fiber have the most bending strength compared to other samples. This is because the fiber pieces arranged in composites are 2 g and composites are 6 g longer than fibers arranged at the composition of 4 g fiber, and fiber composition 8 g. Then the load from matrix to fiber is smaller and interfacial bonds are stronger because the long fiber at the composition of 6 g fiber provides strengthening properties against composites better.

B. Tensile Strengh Test

Specimen testing uses the ASTM 638D standard. The results of the strong tensile fiber composite *Agave Sisalana* can be seen in Figure 5.

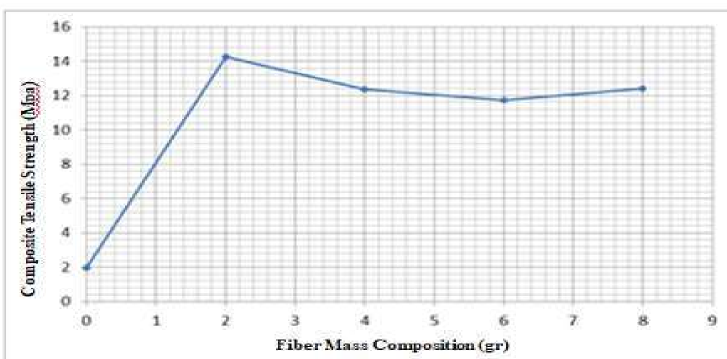

Figure 5. Graph of fiber mass composition with composite tensile strength

Figure 5 shows the resulting composite tensile strength of 1.98 MPa to 14.27 MPa. Without fiber of 1.98 MPa, fiber composition of 2 g of 14.27 MPa, composition of fiber 4 g of 12.36 MPa, composition of fiber 6 g of 11.72 MPa and composition of fiber 8 g of 12.41 MPa. The strong value of pull of each sample is different this is because the increasing composition of the fiber, the more binding between epoxy and natural fiber. Another thing that affects the difference is due to the perpendicular arrangement of fibers that result in many fibers each side of the composite is different. The best tensile strength value at 2 g fiber composition with a value of 14.27 MPa and the lowest is on composites without the addition of fiber with a value of 1.98 MPa.

C. Impact Strength Test

Sample testing is in accordance with ASTM 256 D. Strength test results of the impact composite of *Agave Sisalana* fibers can be seen in Figure 6.

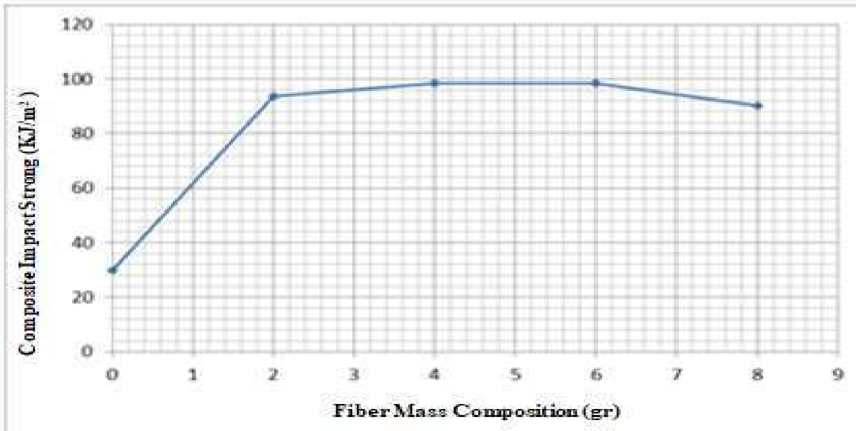

Figure 6. Graph of fiber mass composition with composite impact strength

Figure 6 shows the resulting composite impact strong of 29.52 kJ/m^2 – 90.080 kJ/m^2. The maximum strong impact at the time of composition without fiber is 29.52 kJ/m^2 and the maximum impact strong at the time of fiber composition of 4 g is 98.320 kJ/m^2.

The strength impact on composite *Agave Sisalana* fiber tended to experience a linear increase as the composition of *Agave Sisalana* fibers increases. Strong results of the impact obtained from each angle are the composition without fiber of 29.52 kJ/m^2, the composition of fiber 2 g of 93.680 kJ/m^2, the composition of 4 g of 98.320 kJ/m^2, the composition of fiber 6 g by 95.032 kJ/m^2 and the composition of 8 g of 90.080 kJ/m^2. This shows the composite of *Agave Sisalana* fibers with a fiber composition of 4 g has the strongest impact compared to other compositions. The process of cutting uneven composites that affects the impact strength of the specimen. In addition, the arrangement of fibers that are less straight also affects the strength of the material impact where there is a possibility of voids in the composite.

4 Conclusion

The addition of fiber mass in composite *Agave Sisalana* leaf smelter fiber is very influential as a composite amplifier of natural fibers. With the addition of *Agave Sisalana* fiber mass, the value of testing the physical properties experiences the value of the results linearly. The results of testing the physical and mechanical properties of *Agave Sisalana* fiber composites produce an optimum value of density of 1.064 g/cm^3-1.335 g/cm^3, water absorption 1.59% - 2.62%, porosity 1.7% - 3.5%, strong bending 54.542 MPa – 86.412 MPa, strong impact 29.92 kJ/m^2 – 98.32 kJ/m^2, and strong attractiveness 1.983 MPa – 12.368 MPa. Furthermore, the results showed that the physical and mechanical properties had met JIS Standard A 5905:2003, namely strong bending >32 MPa, the density of 0.3-1.3 g/cm^3, and water content < 25%. Therefore, Agave Sisalana fiber composites with epoxy resin can be applied to car bumpers.

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