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The Effect of Biocomposite Material Composition with Natural Fiber Reinforced Polyester Matrix on Mechanical and Physical Strength

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Abstract:- This study was conducted with the aim of determining the effect of natural fiber composition in polymer composites on the flexural strength and density of bio-composites with polyester matrix reinforced with ramie fiber, giant false agave (GFA), bamboo, and sugar cane fibers. Mechanical testing was carried out in the form of flexural strength testing and calculating density as a physical test. The composition of the matrix with fiber reinforcement was set at 70% polyester and 30% natural fiber. The variables used in this study were to create a dominant composition of fiber types in the form of a measured weight amount so as to produce a comparison of which type of natural fiber has a better test value. From the results of the flexural strength test, it was found that the bio-composite dominated by sugar cane fiber had the largest flexural strength value of 261.66 kg/cm2 while the bio-composite dominated by ramie and GFA sequentially produced flexural strengths of 101.465 kg/cm2 and 185.89 kg/cm2. The results of the density calculation show that the highest density was achieved by the bio-composite material with a dominant composition of hemp fiber (70% Polyester: 20% hemp fiber, 5% GFA fiber: 5% sugar cane fiber) of 1.049 g/cm3.

Keywords:- *Polyester, Hemp Fiber, GFA Fiber, Sugar Cane Fiber, Flexural Strength, Density.*

I. INTRODUCTION

There are many natural fibers from plants that are not optimally utilized to support human life. Fibers consist of hundreds or even thousands of filaments, each filament has a diameter of 5-15 um, so that it can be further processed [1]. Especially Indonesia as a tropical country located right on the equator is covered with various types of plants that can be processed into fibers that have high added value, even often these materials are thrown away, burned, or even become waste that is disturbing and often considered as pests for other plants. Although it cannot be denied that to manage into products that have additional utility value, high technology is needed that has not been mastered by the Indonesian people or the processing tools that have not been able to be made domestically. The most easily found natural fiber materials around us are giant false agave), hemp, and sugarcane bagasse.

Using the capabilities and functions of the three fiber materials together into one material product can be categorized and known as a composite material. Composites generally consist of two elements, namely fiber as a filler and a fiber binder called a matrix. This type of material is the most widely used type and is widely used as a metal replacement application [2], building materials, automotive components, heat retention, sound absorption, and others.

The selection of matrix materials is taken from materials that have ductile properties so that they are able to transmit and withstand the pressure and shear stress received. But for the research conducted, a fibrous composite was developed with a relatively brittle matrix, so polyester was used. Polyester as a matrix can create a relationship between the apparent static energy absorption of various fibers and the dynamic energy absorption of the composite. This is the reason for the widespread use of polymer matrix composites, because of their low price, high strength, and relatively simple manufacturing process [3].

Therefore, recently many natural fibers have been developed to overcome these problems. Natural fibers are more environmentally friendly and safe for human health.

Farid and Heryanto [4] showed the sound absorption performance of hemp fiber-based composite materials in their research. In addition, Farid, et al [5] found a significant

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increase, for polyester material reinforced with hemp fiber for polyester material reinforced with bamboo fiber. The combination of GFA, hemp, and sugar cane fibers as reinforcement then using polyester as the matrix is believed to be a breakthrough in the innovation of creating bio-composite materials that can be applied to significantly affect the results of mechanical and physical strength. With the creation of this material, it is hoped that there will be a revolution in the environment, especially from the use in the field of previous materials that are less environmentally friendly to be more easily decomposed, and are able to reduce waste, and reduce the price of composite products on the market which are dominated by other synthetic materials that are relatively expensive.

II. RESEARCH METHODE

A. Material

The materials used in this study were polyester as a matrix and ramie fiber, GFA bamboo, and sugar cane fibers as reinforcement. Ramie fiber was obtained from wild plants that grow freely in nature, GFA bamboo fiber was purchased from traders who take supplies in the Lumajang area, bagasse fiber was obtained from household waste and PTPN Candi Sidoarjo, and 5% NaOH.

B. Material Preparation

The natural fiber used was subjected to an alkalization process to remove the lignin component by soaking it in 5% NaOH for 24 hours. After that, it was dried and chopped to a small size. The chopped results were blended into a coarse powder which was then refined by grinding using a machine at the fiber and coffee processing facility. Then the size homogenization process was carried out using a sieving machine in the Material Physics laboratory until the size used was 112-224 µmesh. The polyester used was purchased from JUSTUS. With a ratio of polyester and catalyst composition: Polyester: Catalyst (95%: 5%).

C. Specimen Making

The specimen is made by calculating the mass of polyester and natural fiber needed. The mass fraction of the matrix and reinforcement used is 70%:30%. Furthermore, the mass of polyester and natural fiber is weighed according to the volume of the test mold to be used. The method used to mix the matrix and reinforcement is the hand lay-up method.

Table 1 Parameters Used in the Experimental Testing

Specimen code	Matrik (%)	Reinforcement		
	Polyester	Rami	GFA	Sugar cane
I	100	-	-	-
II	70	10	10	10
III	70	20	5	5
IV	70	5	20	5
V	70	5	5	20

D. Flexural Strength Testing

Flexural strength testing was conducted at the Research and Standardization Center (BARISTAND) Surabaya. This test used the 3-point bending method according to the ASTM D709 standard [7] where the specimen was placed on both supports as a holding force in the Y+ direction and was given a load in the middle in the Y- direction. The load given in opposition aims to produce shear stress on the specimen being tested. The test was carried out using two specimens for 1 variable, so that each variable has comparative data. The size of the specimen used was 12.5 x 1.27 x 0.32 cm.

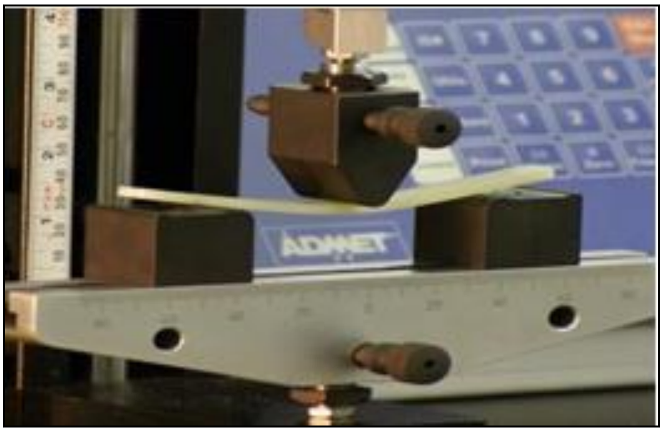

Fig 1 Experimental Setup

Fig 2 Specimen for Bending Tests

E. Density Calculation

Polyester is a rigid material that has voids, conducting tests using formulas and theories based on the ASTM C271-99 standard [8]. Density calculations are carried out by dividing the mass by the volume of the biocomposite material specimen from the sound absorption test. The volume is obtained from measuring the dimensions of the diameter, width and height of the sound absorption specimen. While the mass is weighed with a digital scale with an estimated error of ±0.05.

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III. RESULTS AND DISCUSSIONS

➢ *Flexural Test Results*

From the results of the flexural strength test carried out on all samples, where 2 samples were made for each variable for testing, the flexural strength of each bio-composite material was obtained with a composition according to the initial design in Table 2.

Table 2 Result of Bending Tests

Specimen code		Bending strength (Kg/cm^2)	Average of bending strength (Kg/cm^2)
I	A	724.5	990.82
	B	1257.14	
II	A	51.32	114.75
	B	178.18	
III	A	113.88	101.46
	B	89.05	
IV	A	201.36	185.89
	B	170.42	
V	A	289.77	261.66
	B	233.55	

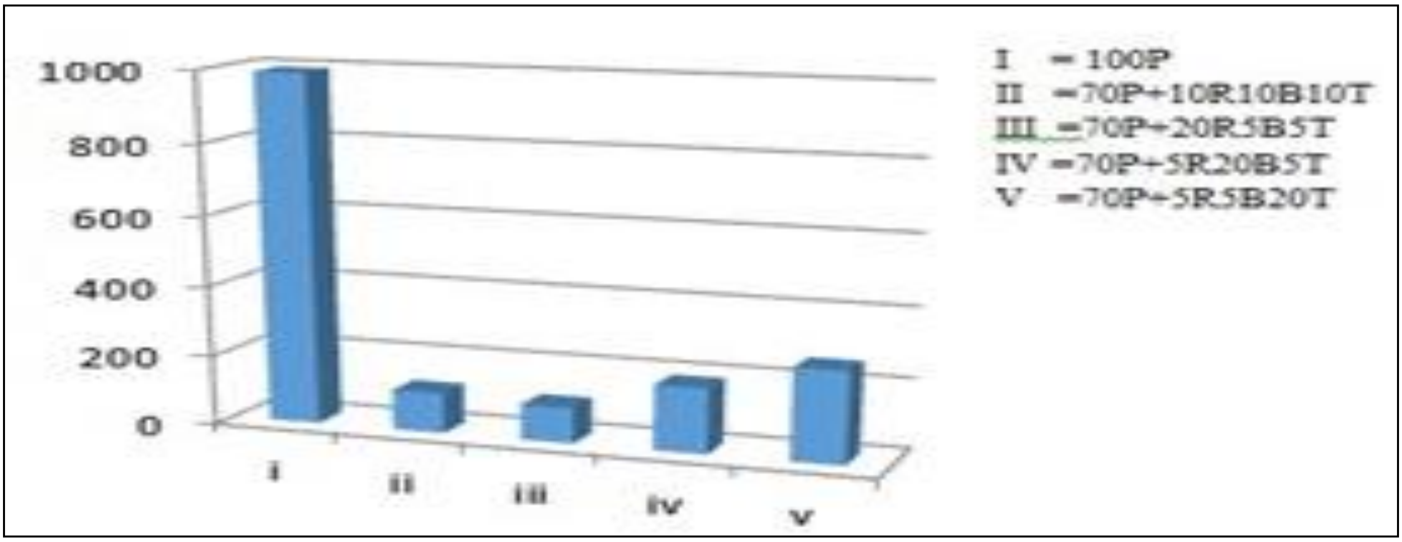

Fig 3 Comparison of Bending Strength

Figure 3 shows that the highest flexural strength is in specimen I where the composition is 100% polyester, reaching 990.82 Kg/cm2. However, because the composition is only polyester and is not mixed with other materials, it cannot be called the composite test strength. Specimen I is only used as a comparison for polyester as a matrix combined with natural fibers as reinforcement. From the graph and table, we can see that the composite material that has the highest flexural strength is in specimen V where the flexural strength reaches 261.66 Kg/cm2 with a composition of 70% polyester with 5% hemp fiber, 5% bamboo fiber, and 20% sugar cane fiber. While materials II, III, and IV each have flexural strength values of 114.75 Kg/cm2, 101.465 Kg/cm2, and 185.89 Kg/cm2. According to Pankaj Pandey et al. [9], the factor of making composite specimens, and the distribution of these fibers can cause the flexibility value of the composite with hand lay up to decrease. This is because when in the process of making composite materials using the manual hand lay-up method, there will be a tendency for fiber saturation to occur at certain points, causing the distribution of fibers throughout the surface area to be uneven, in addition, this can be caused by the inhomogeneity of the composite, resulting in a flexural strength that is different from the theory [10]. So based on the test results, the composite material whose reinforcement is dominated by sugar cane fiber has the best flexural strength if it is to be applied to a model.

➢ *Density Calculation Results*

To get the numbers to calculate the density based on the ASTM formula and standard used, the density of each specimen is first measured by calculating its volume and mass. Then a comparison is made between the density in theory and the density in the experiment. From the experiment, the density value of the composition of hemp, bamboo and bagasse fibers with a polyester matrix was obtained using the mass fraction of each with the composition (I) 100% polyester, (II) 70% polyester with 10% hemp fiber, 10% bamboo fiber, and 10% sugarcane fiber, , (III) 70% polyester with 20% hemp fiber, 5% bamboo fiber, and 5% sugarcane fiber, , (IV) 70% polyester with 5% hemp fiber, 20% bamboo fiber, and 5% sugarcane fiber, , (V) 70% polyester with 5% hemp fiber, 5% bamboo fiber, and 20% sugarcane fiber in Table 3.

Table 3 Density based on Literatures

Specimen code	Density (gr/cm^3)
Polyester	1.10
Rami	1.50
Bamboo	0.25
Sugar cane	0.24

Table 3 is the density of the materials used in making the composite before mixing, so measurements are taken on the specimen to compare the density changes that occur when the material has not been formed into a composite and has been formed into a composite.

Table 4 Density of the Specimen after the Matrix and Fibers are Mixed into a Composite Material

Specimen code	Mass (gr)	Diameter (cm)	Thick. (cm)	Vol. (cm3)	Density (g/cm3)
I	76.7	9.3	10	74.3	1.1
II	77.9	9.8	10	75.5	1.1
III	77.2	9.7	10	73.6	1.1
IV	69.5	9.8	10	75.7	0.9
V	69.4	9.8	10	74.6	0.9

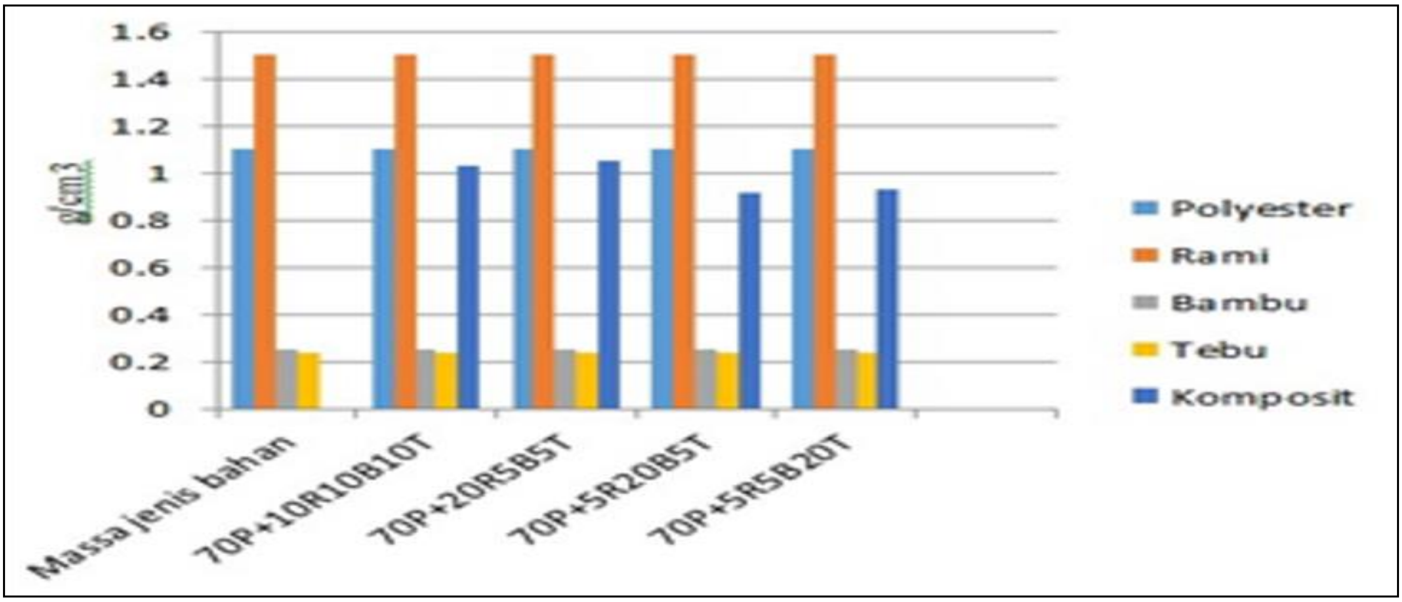

Fig 4 Density Calculation Result Graph

From the results of the calculation and measurement of the composite density carried out, there was almost an increase in density in all composite materials when compared to materials whose densities were obtained from the results of literature studies. The decrease only occurred in composite materials whose fiber mixture was dominated by hemp fiber.

IV. CONCLUSION

- The bio-composite material with the highest flexural strength is found in the composition dominated by sugar cane, with a flexural strength reaching 261.66 Kg/cm2 having a composition of 70% polyester with 5% hemp fiber, 5% bamboo fiber, and 20% sugar cane fiber.
- The highest bio-composite density value is found in a mixture with specifications of 70% polyester with 5% hemp fiber, 5% bamboo fiber, and 20% sugar cane fiber, with a value reaching 1.048991 g/cm3.

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