EFFECT OF VOLUME FRACTION OF GENETICALLY MODIFIED ORGANISM (GMO) SUGARCANE BAGASSE FIBER ON THE MECHANICAL PROPERTIES AND MORPHOLOGY OF BIOCOMPOSITE

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ABSTRACT

Science and technology are currently developing in all fields, such as vehicle construction, building construction, industry, and materials engineering. Especially in the field of material engineering used for the manufacture of composite materials. Currently the transition of materials from metal to composites is also in great demand in various fields including in the automotive, transportation, shipping, aerospace, health, and various other fields. In the components of a vehicle, the components that have the most potential to be reduced are the main structural components, namely the floor, body, and ribs. Efforts to reduce the weight of the material in these components are carried out to reduce the amount of fuel consumption, so the ratio of strength and density of a material is one of the important properties that needs to be considered. This study used the hand lay up method with a comparison of volume fraction variations of 15%: 85% and 20%: 80%. With the aim of adding volume fractions with optimal combinations, it is hoped that the tensile strength will get better. The highest average tensile strength is with a volume fraction ratio of 15%: 85% of 19.04 MPa. While the lowest average tensile strength is with a volume fraction ratio of 20%: 80% of 17.78 MPa. It can be concluded that with increasing fiber volume fraction, the tensile strength decreases. This happens because there are several defects in the form of holes and voids which indicate poor bonding between the fibers and the matrix.

Keywords: PRG sugarcane fibers, volume fraction, epoxy, tensile properties

INTRODUCTIONS

Science and technology are currently developing in all fields, such as vehicle construction, building construction, industry, and materials engineering. Specifically in the field of materials engineering, it is used to manufacture composite materials [1]. Composites are the combination of two or more materials at the macroscopic level (the level that is directly visible) to create new, more useful materials. Composites consist of a binding material (matrix) and reinforcing material (reinforce) [2]. Currently, the transition from metal to composite materials is also in great demand in various industries, especially automotive. The choice of material from metal to composite is because composites have low mass and high mechanical strength and can be made as desired.

For vehicle parts, the components that can be reduced the most are the most important structural parts, viz. floor, body, and ribs, which aims to reduce the material weight of these components to reduce fuel consumption. Therefore, the ratio of material strength to density is an important characteristic to consider. One possible solution is to replace the main structural parts with composite materials [3].

The rapid development of the automotive industry has encouraged the growth of the automotive accessories industry as a supporter of this industry. the production of car accessories, not including suppliers to factories or known as OEMs (Original Equipment Manufacturer), in this regard also fulfills the needs of consumers (aftermarket) in domestic and international markets, we must try to utilize natural fibers as raw materials for the automotive industry synthetic fiber substitutes, for example sugar cane bagasse which is abundant in Indonesia and is considered worthless waste. However, this waste cannot be utilized optimally, even though it has been utilized as optimally as possible by burning it as reboiler fuel, this does not increase the value of bagasse [4]. In the last decade, natural lignocellulosic fibers derived from plants have been widely developed as reinforcement for polymer composites, especially sugar cane, which is often used in the automotive industry, especially car parts in Brazil [5]. Related studies on the effect of increasing the volume fraction of sugarcane fiber on the tensile strength of epoxy by [6] with variations in the fiber volume fraction of 5%, 10%, 15% where the addition of the volume fraction resulted in an increase in the tensile strength.

With the references obtained, the author conducted research on the effect of variations in the volume fraction of PRG bagasse fiber on the tensile strength and morphology of bio composites.

METHODOLOGY

The method used in this research is the hand lay-up method, which is a simple process using the open composite method [7]. Data processing uses one-way ANOVA statistics which aims to determine the contribution of the independent variable, in this case the volume fraction to the tensile strength value. This research testing used a UTM HT-2042 tensile testing machine and SEM observations using a Hitachi TM3000 with a magnification of 20-30,000x. Tensile testing was carried out three times for each variation. Tensile testing specimens according to ASTM D638.

Materials

Tools and materials in this research include:
a. Digital balance sheet
b. Blender
c. Aqua glass
d. Mesh 80
e. Scissors
f. PRG sugarcane fiber
g. Epoxy resin and epoxy hardener

Preparation of Sugarcane Bagasse

1) Dry the bagasse fiber in the sun for 5-7 days until completely dry.
2) The bagasse fiber is separated from the skin and cut to get the desired fiber.
3) The bagasse fiber is then put into a ceramic glass and covered with aluminum foil. (for sugarcane bagasse fiber which is not processed directly into the milling process using a blender to obtain powder form)
4) Put the coated ceramic glass into the furnace at a temperature of 600° C for 1 hour and then cool it to room temperature.
5) Selection of bagasse powder using mesh 80 to obtain a powder size of no more than 177 µm.

Stages of Composite

1) Prepare bagasse powder with and without processing to be used as a comparison.
2) Mix the bagasse powder (alternately with and without mixing) with the matrix according to the predetermined volume ratio using an aqua glass and a stirrer evenly.
3) Mixed sugarcane bagasse powder and matrix are poured into the mold provided.
4) Dried and hard bagasse powder composite is removed from the mold.

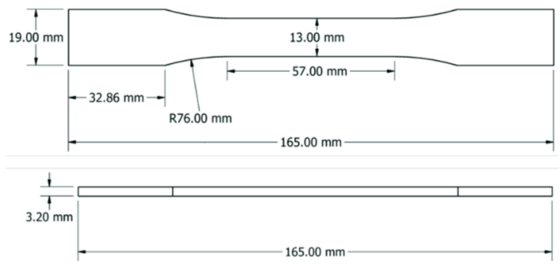
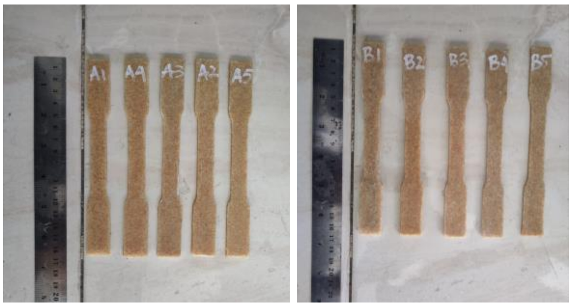


Figure 1. Tensile testing specimens according to ASTM D638.

RESULT AND DISCUSSIONS

The results of making bio composite specimens with an epoxy matrix are shown in Figure 2 below.



(a) (b)

Figure 2. Tensile test specimens with comparison (a) 15%: 85%, (b) 20%:80%

Tensile strength is the limit of a material's ability to withstand the tensile load that can be absorbed by the product or material before failure or fracture occurs [8]. The graph of the tensile test data can be seen in Figure 3.

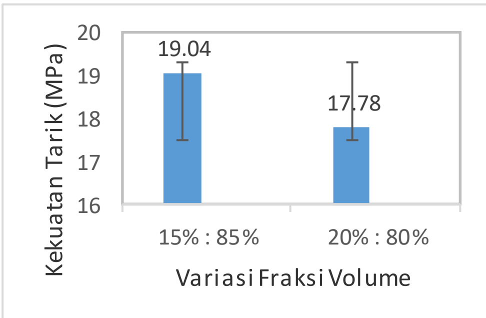


Figure 3. Tensile strength

From the observations it is known that the tensile strength decreases with increasing volume fraction. The decreasing tensile strength value is influenced by poor bonding between the fiber and the matrix [9].

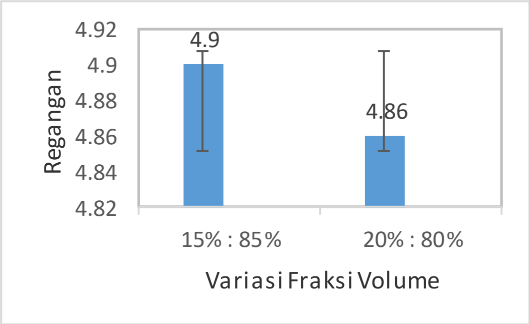


Figure 4. Tensile strain

The tensile strain value decreases with increasing volume fraction. The tensile strain value shows the ability of the object to change shape and the decrease in tensile strain is the cause of the strength of the bond between the reinforcing fibers and the matrix where the stronger the bond, the smaller the strain value will be [10].

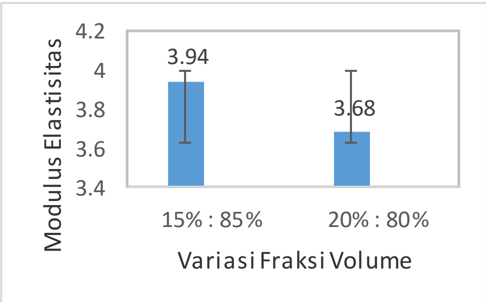


Figure 5. Modulus elasticity

It can be seen in Figure 5. The elastic modulus value decreases with the addition of volume fraction. The decrease in the elastic modulus value is caused by a significant difference in the tensile strength value compared to the tensile strain value. This situation means that the tensile strain is not directly proportional to the tensile strength [11].

Anova (*One Way*)

Analysis of variance is a method used to determine the contribution of the independent variable, in this case the volume fraction, to the tensile strength value without editing by comparing the calculated F with the F table at = 5%. In this study, the F table value used was F(0.05;1;8) 5.32.

a. Sum of mean squares

$$JK_R = R_y$$

$$JK_y = \frac{[184{,}08]^2}{10} = 3388{,}544$$

b. Sum of squares between treatment

$$JK_p = P_y$$

$$JK_p = \frac{[Total\ A1]^2}{n1} + \cdots \frac{[Total\ As]^2}{ns} - \frac{[Total\ A]^2}{n1 + \cdots + ns}$$

$$JK_p = \frac{[19{,}84 + 18{,}84 + 14{,}61 + 20{,}33 + 21{,}96]^2}{5} + \frac{[16{,}60 + 17{,}96 + 16{,}94 + 18{,}61 + 18{,}78]^2}{5} - \frac{[183{,}37]^2}{10}$$

$$JK_p = \frac{[95{,}18]^2}{5} + \frac{[88{,}19]^2}{5} - \frac{183{,}37]^2}{10}$$

$$= 1827{,}107 + 1580{,}286 - 3388{,}544 = 18{,}849$$

c. Sum of total squares

$$JK_T = \sum Y^2$$

$$JK_T = 19{,}84^2 + 18{,}84^2 + 14{,}61^2 + 20{,}33^2 + 21{,}96^2 + 16{,}60^2 + 17{,}96^2 + 16{,}94^2 + 18{,}61^2 + 18{,}78^2$$

$$JK_T = 393{,}6256 + 354{,}9456 + 213{,}4521 + 413{,}3089 + 482{,}2461 + 275{,}56 + 322{,}5616 + 286{,}9636 + 346{,}3321 + 352{,}6882$$

$$= 3441{,}683$$

d. Sum of squared errors

$$JK_g = JK_T - JK_R - JK_p$$

$$JK_g = 3441{,}683 - 3388{,}544 - 18{,}849 = 34{,}29$$

e. Mean square.

$$KT_R = JK_R$$

$$3388{,}544 = 3388{,}544$$

f. Middle square

$$KT_p = JK_p : DK_p$$

$$KT_p = 18{,}849 : 1 = 18{,}849$$

g. Middle square error

$$KT_g = JK_g : DK_g$$

$$KT_g = 34{,}29 : 8 = 4{,}286$$

h. Count of F

$$KT_p : KT_g = 18{,}849 : 4{,}286 = 4{,}397$$

The complete results of the anova calculation above can be seen in table 1.

Table 1. Anova calculation result

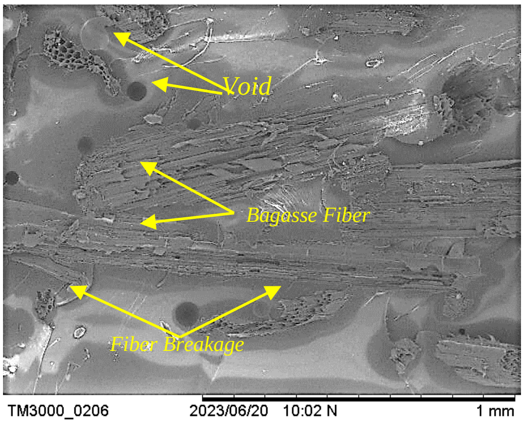
Variant	Dk	JK	KT	F
Mean	1	3.388,544	3.388,544	
Between treatment	1	18,849	18,849	4,397
Experimental fallacy	8	34,29	4,286	
Total	10	3441,683	-	-

In this study, with increasing volume fraction, the tensile strength obtained became lower. This result is in accordance with research conducted by [9] which stated that the decrease in tensile strength was caused by poor interfacial bonding between the fiber and the matrix. Fiber fragility also contributes to low mechanical strength due to more fibers, allowing it to withstand heavier loads.

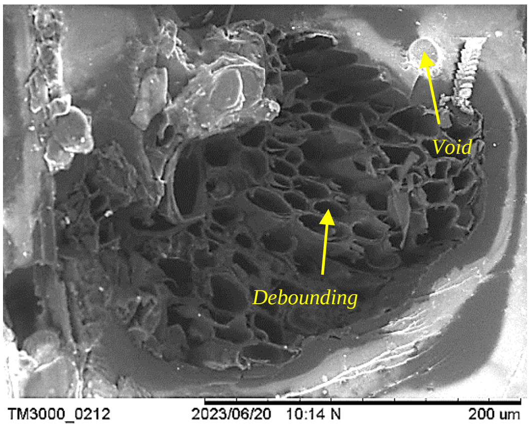
From the analysis results, the calculated F value is 4.397, which is smaller than the F table, namely 5.32. It can be concluded that the volume fraction does not significantly affect the tensile strength value obtained, which indicates that H0 is accepted, meaning that there is no significant influence of the volume fraction on the tensile strength.

***Scanning Electron Microscope* (SEM)**

This test was carried out to show the bond between the matrix and the reinforcement at the fracture of the composite sample. The results of SEM observations can be seen in Figure 6.



(a)



(b)

Figure 6. SEM magnification: (a) 100x, (b) 500x

From the results of SEM observations, in the image there are many fractures and several defects. The presence of fiber breaks indicates that the bonds between the fibers are well bonded, which means the fibers are completely wetted with the matrix. The picture also shows several defects in the form of holes and voids. These holes indicate loose fibers or debonding. This indicates poor bonding between the fibers and the matrix and when pressure is applied causes the fibers to be easily pulled out of the matrix, leaving gaping holes [12].

CONCLUTIONS

Increasing fiber volume fraction, the tensile strength value decreases. And the SEM observation results show several defects in the form of holes and voids. This is caused by poor bonding between the fiber and the matrix.

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