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Tensile Strength of Potent Cars Bumpers Materials from The Woven Ramie Fiber

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ABSTRACT

Suburban communities around Cilegon usually depend on urban mass transportation. The vehicle has very high mobility when peak hours. Infrequently, this consequent collision and friction between them in the crowd of traffic jams. It causes damage or crushing of their bumper. Hence, a material that has suitable qualifications is needed. One of the materials which have the potential strength to be applied as a bumper car is ramie fiber. As a fiber, this material has high tensile strength properties. In this research, we need to ensure that woven ramie-epoxy composite has a tensile strength value above the standard for car bumper material. The composite consists of woven ramie as the matrix and epoxy resin as the filler at a weight ratio of 40:60. Application curing treatment to the composite with 0-30-60-90-minute. The tensile test results are 30.6 MPa, 36,4 MPa, 36,5 MPa, and 40,8 MPa - the highest values at 90-minute CT. All tensile strength value of the composite is above the standard value required. It also found that the composite water absorption was below the limit of the standard. Based on those values, the woven ramie-epoxy composite can be considered a potent material for use as a bumper car.

Keywords: *Composite, Woven Ramie, Epoxy Resin, Tensile Strength, Potent Car Bumper Material.*

1. INTRODUCTION

Suburban communities around Cilegon usually depend on urban mass transportation (Figure 1). This vehicle is a minibus consisting of two compartments, the front consisting of a driver's seat and a passenger, and the rear consisting of six passenger seats facing each other [1].

Figure 1. Urban mass transportation in Cilegon City serves the suburban community.

Figure 2. Car Bumper of an urban mass transport vehicle of Cilegon City after colliding.

The vehicles have very high mobility when serving workers, school children, and women when they go to the market [2]. The collisions and friction between them, especially in the crowd of traffic jams. Infrequently this consequently damages or cruses the bumper vehicle.

A car bumper is a car component that functions as safety in the event of a collision (Figure 2) [3–5]. The use of car bumpers began in 1930 in America [6]. The bumpers were made of thick steel plates and used only on their vehicles' front. In the 1950s, Buick, an American automaker, introduced a bumper featuring a vertical grille bar. Starting to enter the 1960's bumper cars began to be made of thin iron plates. It didn't last long because it was still inefficient and heavy. It wasn't until 1970 that the car bumper used plastic fiber bumpers in their cars to this day (Figure 3).

Figure 3. Plastic fibers materials have become common car bumpers materials.

The car's bumper serves as safety in the event of a collision. This component must have a good classification that follows The *Original Equipment Manufacturer* (OEM) standard. It also needs to be low cost for repair [7]. They are commonly made from plastic materials. In the last decade, many car bumpers have been made from fiber composite materials [5]. Generally, this composite consists of two material components: matrix and filler. The ramie fiber material, which forms woven fiber, functions as a matrix. The cavity between the fibers is occupied with epoxy, which works as a filler. This material has several advantages over plastic materials. Among other things, they are easy to repair some damage. The fibers used vary, such as synthetic and natural fibers [8–12].

The use of natural fibers in the manufacture of composites is being investigated. Research on the manufacturing process of bamboo fiber composites with epoxy using the Hand Lay Up method produces a material with an optimal tensile strength of 240 MPa at 3 hours of curing time. The lowest is 204 MPa at 4 hours of curing time. This value states that bamboo composites are considered worthy of being an alternative material in automotive production [13]. Research on the effect of curing temperature on betel nut fiber composites at temperatures of 0 °C, 60 °C, and 90 °C showed that 90°C resulted in a high value of modulus of elasticity compared to the temperature of 60 °C and that which was not cured [7]. Meanwhile, Research on oven use and hot oil on banana midribs shows that the use of ovens for curing results in better composite quality than the use of oil [14]. Furthermore, Research on the tensile strength of ramie-epoxy composites to be used as an alternative material for car bumpers shows that the values obtained are still above the allowable tensile test values for car bumper materials [15]. The tensile value indicates that the material is feasible to be an alternative material in manufacturing material bumper components.

Based on Saidah's Research, we need to ensure that the use of Ramie-epoxy as a composite has a tensile strength value above the standard required for car bumper material. The curing treatment applied to the composite also increased the material's tensile strength, which advantage of curing temperature to rise in tensile strength value will discuss in this paper.

2. METHODOLOGY

2.1. Materials

The composite materials consist of two components. First is a woven ramie from the commercial product becomes the matrix (Figure 4), and an epoxy resin technical grade from the market becomes the filler. Both materials become composites with a weight ratio of 40:60 of woven ramie and epoxy resin.

Figure 4. The woven ramie from the commercial product.

2.2. Curring treatment

The curing process is treating after the composite material becomes solid with heating temperatures above room temperature using an oven [16]. The polymerization process on the resin that fills the cavities between the ramie fibers forms a stronger attachment to fibers. The curing treatment is applied to the composite at a temperature of 70 ^{o}C with variations times of 0 minutes, 30 minutes, 60 minutes, and 90 minutes.

2.3 Tensile Test
The tensile test is carried out to determine the tensile strength of the composite specimen. The specimen is made following the ASTM D3039 standard (Figure 5). Furthermore, the tensile strength value of the composite, compared with the standard JIS A 5908 (2003), states that the tensile strength value of car bumper materials cannot be less than 8.09 MPa.

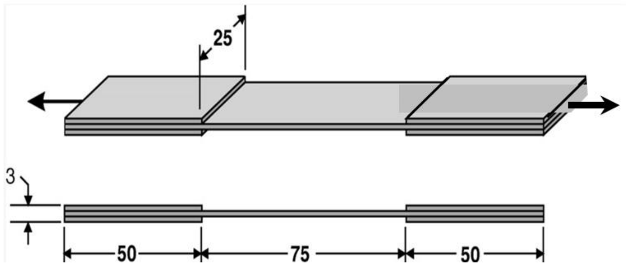

Figure 5. Specimen test shape for ASTM D 3039 standard.

2.4 Water Absorption
The water absorption test to determine the quality and strength of the ramie-epoxy composites [17–24]. The percentage of water absorption in the composite calculation is using the equation:

$$WA = \frac{M_b - M_k}{M_k} \times 100\%$$

Where as,
WA : Water Absorption %.
M_b : The sample mass after being immersed in water (gr).
M_k : Sample mass before soaking in water (gr).

Referring to the JIS A5908-2003 standard that the maximum threshold for water absorption in composites for car bumpers is not more than 12% [25].

3. RESULTS AND DISCUSSION

3.1. Tensile Test
Tensile testing was carried out to determine the elasticity strength of the woven ramie-epoxy composite [19,26,27]. The following figure shows the results of the tensile test that has been carried out on all samples (Figure 6).

The results of the tensile strength of the composite at various curing times (CT) obtained values of 30.6 MPa, 36,4 MPa, 36,5 MPa, and 40,8 Mpa. This value shows that the composite had tensile strength above JIS standard value for car bumper. The highest tensile strength value reaches 90 minutes of CT. the increasing tensile strength value shows that the CT has an advantage in increasing the tensile strength.

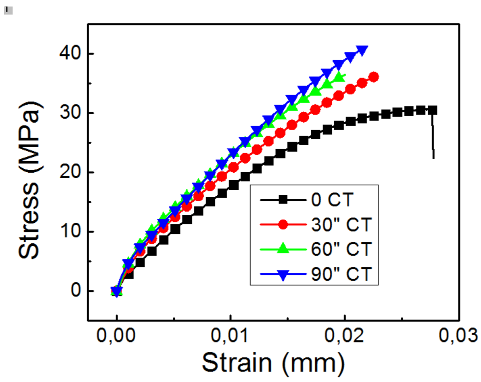

Figure 6. Graphics of Stress and Strain value of composite with 0, 30, 60, and 90 minutes CT..

3.2. Morphology
The morphology of surface fracture from the tensile test specimen is identified with An Optical microscope with a magnification of 50x. The fracture results of the samples with curing treatment for 0-30-60-minute CT have shown the occurrence of pullout defects. The pullout defect happens because the filler needs to be perfectly attached to the matrix.

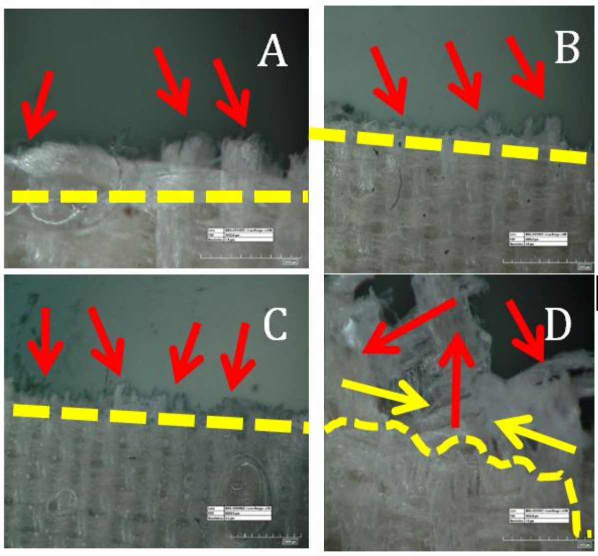

Figure 1. Morphology of Tensile Test result of A) 0-minute, B) 30-minute, C) 60-minutes, and D) 90-minute of CT treatment. The red arrows show the fiber getting pullout as the matrix, and the yellow marker shows the cracking border of the filler.

At 90 minutes CT, the fracture results on the composite specimen pieces showed that the composite was shrinking before breaking. It can be seen that the woven ramie fibers tend to pack towards the center, and the epoxy parts are wrinkled and pushed up to form irregular break patterns. It also appears that increasing CT has increased the value of the composite sample's stress resistance and the composite's elastic properties [15].

3.3. Water Absorption

Water absorption testing was carried out to determine the quality and strength of the ramie fabric composites. A good composite has negligible water absorption where the number of pores on the surface is slightly tight. It is very influential on the quality of the resulting bumper. The following are the results of the water absorption test [21].

The results of the water absorption test showed a tendency to increase linearly in terms of CT since one of the characteristics of ramie fiber is that it can absorb water greater than epoxy resin [28]. The water absorption behavior from the standard car bumper should be at most 12%. The water absorption data of the composite shows the water content has increased in line with the immersion time but is still below 12%, which allowed the value of the car bumper.

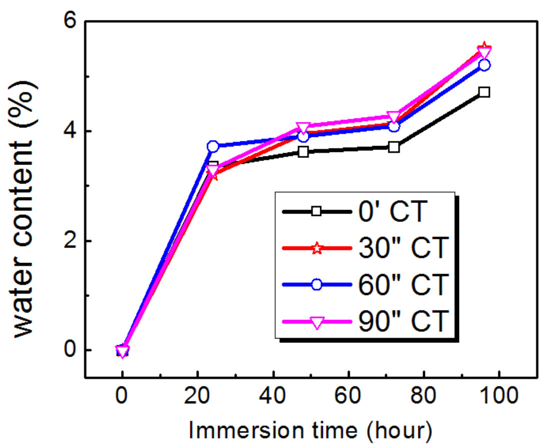

Figure 10. Graphics of water absorption of the composite Graphics of water absortion.

4. CONCLUSION

The manufacture of woven ramie-epoxy composites for car bumper alternative materials has been successfully carried out.

Tensile test results for the composites show that the tensile strength value exceeds the minimum allowable standard. The results of the water absorption test also show that the water absorption value of the composite is still below the permissible standard value. Based on these two test values, the woven ramie-epoxy composite can be considered a potent material for use as a bumper car.

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