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Flexural Strength of Bamboo Fiber Composite Material as an Alternative Material for Making Car Spoiler Products

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Abstract. Bamboo fiber is one of the many natural fibers produced in Indonesia. It is environmentally friendly and useful for various purposes in making products. This study aims to develop bamboo fiber as an alternative material for making automotive components, namely spoilers. Car spoiler products have several functions, among others, to provide an aerodynamic effect and as accessories that give an aesthetic impression to the car. The research focused on the flexural strength produced by bamboo fiber composites as an alternative material for making spoiler components. Preparation of test samples and flexural strength testing were carried out using the ASTM D 730-03 standard. Based on the results of the tests, bamboo fiber composites have good flexural strength and can be developed into car spoiler materials. The results of this study will be one of the references for further development. Keywords: bamboo fiber, car spoiler product, flexural strength.

INTRODUCTION

Car spoiler products are widely used to overcome aerodynamic problems in cars and the need for accessories as part of car aesthetics. A spoiler on a car can reduce the resistance that occurs when driving at a certain speed. Crouse et al. suggest that the power used to overcome air resistance (drag) on a car moving at a 145 km/h speed reached 75%. The value will increase at a lower car speed. Thus, spoilers are indispensable accessories if you are going to control and regulate the aerodynamic characteristics of cars, especially cars with medium to high speeds [1-4].

In general, spoilers increase downforce or downward pressure on the car, thereby reducing the lift caused by the car's speed. The uncontrolled lifting force of the vehicle makes it feel hovering and unstable, making it difficult to control. By installing the appropriate spoiler, the car's wheels will remain firmly attached to the road, making it easy to control. Spoilers are installed at the back of the car, either in the trunk or on the roof. At the same time, additional spoilers can be installed on the front, right, and left sides of the car [5-7]. The car spoiler product was developed using various materials, including ABS plastic and fiberglass composites. In this study, spoiler products were developed using bamboo fiber composite materials. Bamboo fiber is a natural material abundant in Indonesia and is still not appropriately utilized to produce automotive component products.

Several research results of bamboo fiber composites are references in this study. The research results by Arfie Armelia Erissonia Ifannossa et al. [8] showed that the value of Young's modulus for strand bamboo fiber composites with a direction of 0º and woven bamboo fiber composites with a direction of 0º/90º was quite large. However, for specimens of strand bamboo fiber composites with a direction of 90º and woven bamboo fiber composites with a direction of +45º/- 45º, the value of Young's modulus is small because the fiber directions of 90º and +45º/-45º are not strong enough to withstand longitudinal tensile loads. The failure that occurred in the specimen was caused by the adhesive in the form of epoxy resin which was not strong enough to withstand the shear load. As a result, the resin was separated from the fiber. The fracture occurs near the clamp because there is a high concentration of stress around the clamp area and the specimen cannot withstand it. Ultimate strength for strand bamboo fiber composites with a direction of 0° and woven bamboo fiber composites with a direction of 0°/90° has a higher value compared to strand bamboo fiber composites with a direction of 90° and woven bamboo fiber composites with a direction of +45°/- 45º. That result states that the ultimate strength value will be higher if the test is given a tensile load in the direction of the fiber [9-10]. The study results by Danny Eldo et al. (2010) showed that the adhesive bond between the face and the core plays an important role in the strength of the sandwich structure of the bamboo fiber with polyurethane composite. Specimens experiencing delamination failure mode on average have lower strength than specimens that do not experience delamination [11]. Iwan

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Supriyanto et al (2009) tested the shear strength of laminated bamboo using polymer isocyanate adhesive in two types of conditions, namely interior and exterior. In the interior condition, the maximum shear strength is 12.93 MPa with a mass of 225 g/m^2, while in the exterior condition, the maximum shear strength is 10.08 MPa with a mass of 225 g/m^2. The Petung's bamboo used in the test has an average shear strength value of 4.5 MPa [12].

This study aims to obtain the flexural strength of the bamboo fiber composite material implemented in spoiler products. Spoiler products require good strength, especially flexural because spoilers are usually installed using bolts on both sides of the spoiler end. At the same time, the length of the spoiler produces a fairly long stretch along the width of the car. When walking and receiving vibrations due to uneven roads, the spoiler will receive a reasonably strong vibration load and affect the strength of the bolt mounting holes or on the stretch. Therefore, good flexural strength is needed so that the spoiler product can work properly and be safe from vibration.

METHOD

This research was conducted by making composite test samples and spoiler product prototypes using continuous strips of bamboo fiber. The chosen matrix is epoxy resin. Bamboo fibers (strips) are made into woven bamboo with the size of bamboo strips 1 mm thick, 3 mm wide, and the distance between the fibers is 5 mm, as shown in Figure 1.

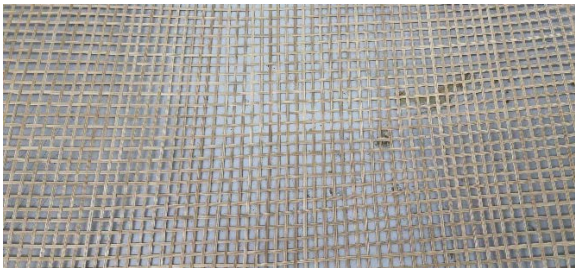

FIGURE 1. Bamboo fiber woven

The woven bamboo is then laminated using epoxy resin in a positive mold to make a spoiler. After the lamination process is complete, the spoiler product is removed from the mold and painted according to the desired color. Prototyping of spoiler products (Figure 2) is carried out in collaboration with Small and Medium Enterprises that focus on the manufacture of car accessories products, at a cost that is not too expensive.

FIGURE 2. Prototype of spoiler product

To ensure the strength of this spoiler product, a test sample was made by cutting the sample from the spoiler product according to the ASTM D 730-03 flexural testing standard. The test results were then analyzed to determine the flexural strength of the spoiler product with epoxy bamboo fiber composite material.

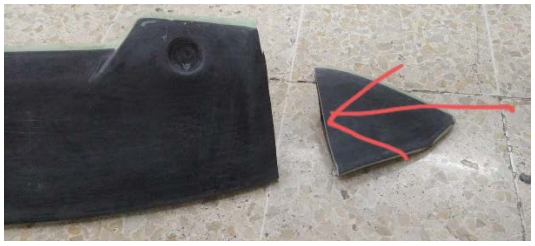

FIGURE 3. Test sample preparation

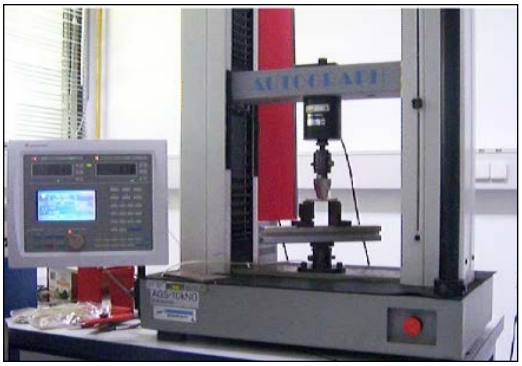

FIGURE 4. Bamboo Fiber Composite Flexural Test

Results and Discussion

Flexural testing of bamboo fiber composite materials has been carried out, which will be used as an alternative material to make car spoiler products. Spoiler products need flexural strength to accept vibration and wind loads when the car moves at a certain speed, especially on uneven roads. The flexural strength test of the bamboo fiber composite test sample refers to ASTM D 730-03.

Based on the tests that have been carried out, the following results are obtained:

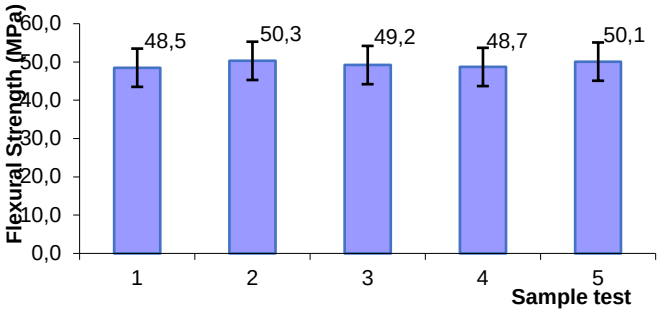

FIGURE 5. Flexural Testing Result

Figure 5 shows the results of the flexural strength test. The average flexural strength was 49.4 ± 0.81 MPa. The flexural strength of the epoxy bamboo fiber composite material is very good. This finding strongly supports the process of developing epoxy bamboo fiber composites as an alternative material for making spoiler products to replace synthetic fiber composite materials, especially fiberglass and ABS plastic. Compared to spoilers made of ABS plastic and rattan fiber composites, the flexural strength of bamboo fiber composites is between the two materials. The average flexural strength of spoiler product made from epoxy rattan fiber composite material is 45.35 ± 0.89 MPa and spoiler product made from ABS plastic material is 55.72 ± 3.53 MPa [13-15].

Table 1. Typical Flexural Strength and Flexural Modulus of Polymers [16]

Polymer Type	Flexural Strength (MPa)	Flexural Modulus (GPa)
ABS	75	2.5
ABS + 30% Glass Fiber	120	7
Acetal Copolymer	85	2.5
Acetal Copolymer + 30% Glass Fiber	150	7.5
Acrylic	100	3
Nylon 6	85	2.3
Polyamide-Imide	175	5
Polycarbonate	90	2.3
Polyethylene, MDPE	40	0.7
Polyethylene Terephthalate (PET)	80	1
Polyimide	140	3
Polyimide + Glass Fiber	270	12
Polypropylene	40	1.5
Polystyrene	70	2.5

When compared with ABS plastic which has not been made into spoiler products, it has a flexural strength of 75 MPa, then the flexural strength of spoilers made from bamboo fiber composite material is quite good. Bamboo fiber composites have better flexural strength when compared to rattan fiber composites. This result becomes one of the references for further development. The flexural strength of bamboo fiber composites can be increased by treating the fibers before they are used as composite materials. Improving the production process can also enhance the strength of the composite by reducing the occurrence of debonding, delamination, and voids [13-15].

This research has also produced a spoiler product prototype implemented on MPV cars, as shown in Figure 4. The product prototype is made using a positive mold which is commonly used to make spoilers with glass fiber composite materials. Innovative products using bamboo fiber composites can be used properly and become alternative products to be further developed by improving production.

FIGURE 4. Spoiler Product Prototype with bamboo fiber composite material

CONCLUSION

Research has been carried out to obtain the flexural strength of spoiler products using epoxy bamboo fiber composite materials. This study succeeded in obtaining the flexural strength as planned. The flexural strength of the bamboo fiber composite was better than the rattan fiber composite and slightly lower than the flexural strength of ABS plastic. It is necessary to treat bamboo fiber and improve the manufacturing process to obtain a better and stronger spoiler product. The results of this study are beneficial in the development of spoiler products using bamboo fiber and can be a reference in the development of spoiler products using natural fibers.

REFERENCES

[1]. Crouse, W. H., Anglin, D. L., 1985, *Automotive Mechanics.* McGraw-Hill Book Company. New York.
[2]. Sandy Minkah Kyei, 2014, *Composite Car Rear Spoiler*. Thesis. The Energy and Material Technology Department. Arcada University of Applied Sciences.
[3]. A. Sunanda, M. Siva Nayak, 2013, *International Journal of Emerging Technology and Advanced Engineering* **3**-1-236
[4]. Martin Meindlhumer, Konstantin Horejsi, Martin Schagerl, 2019, *Journal of Aircraft* **56**-1-85
[5]. Hitoshi Fukuda, Kazuo Yanagimoto, Hiroshi China, Kunio Nakagawa, 1995, *JSAE Review* **16**-151
[6]. G. M. Le Good, J. P. Howell, M. A. Passmore, A. Cogotti, 1998, *International Congress and Exposition Detroit*. Michigan.
[7]. Xu-xia Hu, Eric T.T. Wong, 2011, *World Academy of Science, Engineering and Technology* **57**-636
[8]. Arfie Armelia Erissonia Ifannossa, Bambang Kismono Hadi, Muhammad Kusni, 2010, *Prosiding Seminar Nasional Tahunan Teknik Mesin (SNTTM) ke 9* MIV 35-42
[9]. A. Balaji, B. Karthikeya, C. Sundar Raj, 2014, *International Journal of ChemTech Research* **7**-01-223
[10]. Suddell B., 2009, *Proceedings of the Symposium on Natural Fibres* 71 - 82.
[11]. Danny Eldo, Bambang Kismono Hadi, Muhammad Kusni, 2010, *Prosiding Seminar Nasional Tahunan Teknik Mesin (SNTTM) ke 9* MIV 221-230
[12]. Iwan Suprijanto, Rusli, Dedi Kusmawan, 2009, *Prosiding PPI Standardisasi* 1 – 23
[13]. Irawan, A.P., Wayan Sukania, I., Anggarina, P.T., Danendra, A.R., Baskara, G.D., 2020, *IOP Conference Series: Materials Science and Engineering* **852**-1-012042
[14]. Irawan, A.P., Adianto, I Wayan Sukania, 2018, *IOP Conf. Series: Materials Science and Engineering* **420**-1-012015
[15]. Irawan, A.P., Utama, D.W., Affandi, E., Michael, M., Suteja, H., 2019, *IOP Conference Series: Materials Science and Engineering* **508**-1-012054
[16]. Matwab, *Flexural Strength Testing of Plastics.* http://www.matweb.com/reference/flexuralstrength.aspx

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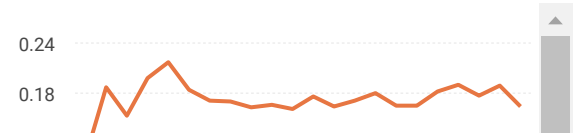

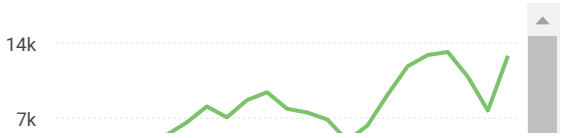

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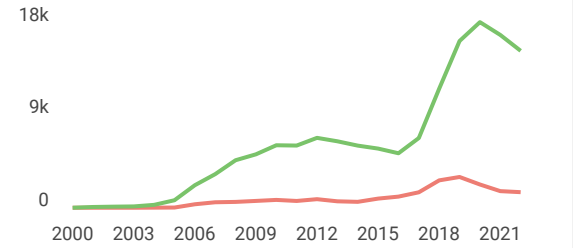

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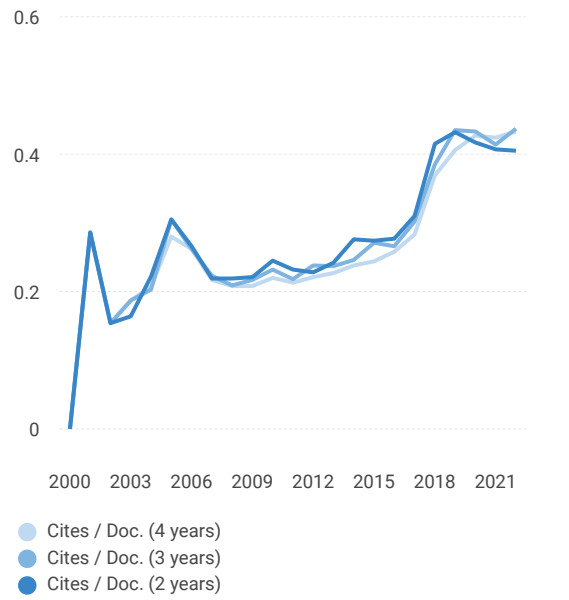

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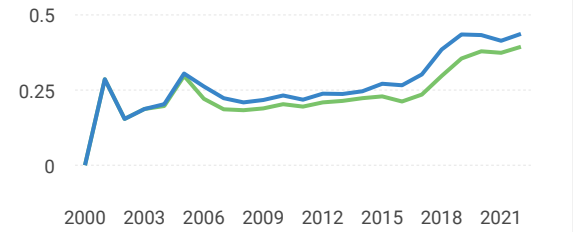

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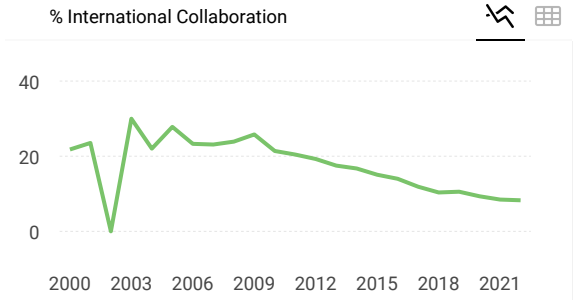

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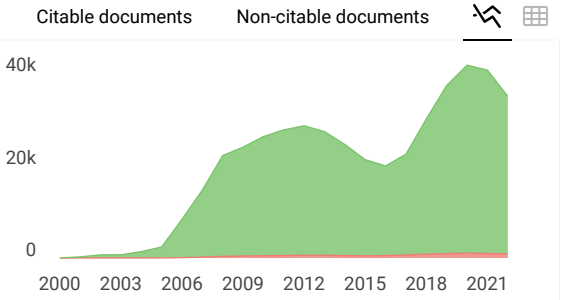

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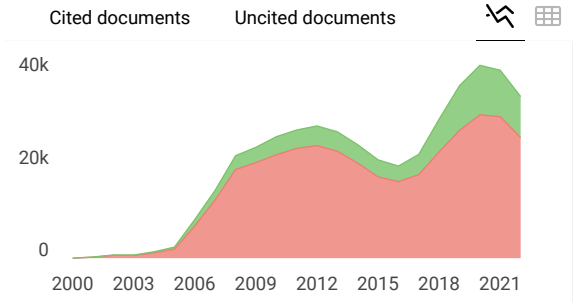

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