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Analysis of Utilization of Pandand Fiber Biocomposite Materials as a Motorcycle Body Kit Using Impact Testing With Charpy Method

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Abstract:
*This study aims to analyze the impact test strength of a mixture of pandan mat fiber with epoxy resin as a test medium for motorcycle body kit materials with fiber orientation directions 0°, 45°, *R° (Random), with a comparison of the composition of the epoxy resin matrix (A). +hardener (B) (A: B/2:1), 95%, 85%, 75%, with pandan mat fiber as 5%, 15%, and 25%, with the Charpy Impact testing method. This test is carried out regarding the JIS Z 2202 impact test standard. In the experiments that have been carried out, it was found that the test object with the code MF-04 with fiber orientation direction 0° with a ratio of the resin composition (A) + hardener (B) (A: B/2:1) as much as 85% and 15% pandan fiber mat. It has the highest fracture strength value of 783 KJ (Kilo Joule) and has the highest ductility value of 9.78 KJ/m^2. Based on the visual observation of the macrostructure, the test object with code MF-04 has a rough fracture surface, and this is similar to the characteristics of ductile fracture. This study concluded that the composite material for pandan fiber mats with a mixture of epoxy resin with specimen code MF-04 with a composition of 85% resin + hardener and 15% pandan fiber mats with 0° fiber orientation direction could be used as an alternative material for motorcycle body kits..*

Key words: *Body Kit, Pandan Mat, Epoxy Resin, Impact Test.*

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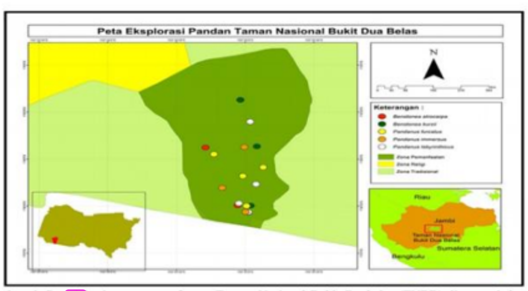
I. Introduction

Jambi is a province on the island of Sumatra. Jambi Province has lowland forests and peatlands with high rainfall, which is the epicenter of the "tropical rainforest" in Sumatra. In Jambi Province, four National Parks are very important to the community, including Kerinci Seblat National Park, Bukit Tiga Puluh National Park, Berbak National Park, and Bukit Dua Belas National Park. One form of local wisdom with pandanus is planted for various purposes ranging from traditional ritual activities to making woven mats and chopsticks (a type of wallet for storing tobacco and cigarettes) made from pandan leaves. Chopsticks are woven products used to store betel and tobacco in the form of a wallet or pocket. Chopsticks have various variations, namely small, medium and large chopsticks[4].



Picture 1. Map of the utilization zone of Bukit Duabelas National Park (TNBD) where several types of pandanus (Pandanaceae) were found (Location of utilization zone in Bukit Duabelas National Park, where the species of pandan were found)

The use of pandan, among others, as a food fragrance such as fragrant pandan (Pandanus amaryllifolius), foodstuffs such as red fruit pandanus (pandanus considers) and forest coconut pandanus (pandanus brosimos, pandanus iwen, and pandanus julianettii), and plaited pandanus such as tanned pandanus (pandanus tectorius and pandanus furcatus). Today's increasing community life, both in urban and rural areas, has impacted the culture and lifestyle of the local community and the preservation of biological resources. Knowledge of the use of biological resources by local communities from generation to generation has begun to erode in line with the entry of advanced technology that is developing today. However, conventional technology products still have their meaning, such as traditional handicraft products, which are well known. Information about Pandanus is still limited, both in terms of species diversity and the population in Indonesia[6].

The development of composite technology is in synthetic composites and leads to natural composites/nature composites (NACO) because they can be recycled, or other terms are renewable (Sulaiman and Rahmat, 2018). The use of polymers and composites today is increasing in all life areas, such as car bumpers, vehicle bodies, aircraft bodies, sports equipment, and others. Fiber-reinforced composites are widely applied to tools that require materials that combine two basic properties, namely strong and light. The trend of composite development today is shifting from composites with synthetic constituent materials to composites with natural ingredients. Many studies have been carried out for both matrix and fiber (reinforcement) materials to obtain natural materials suitable for further use as an alternative to synthetic composite materials. Natural fibers have several advantages compared to synthetic fibers, such as lighter weight, natural processing, and environmental friendliness[2].

There are three materials commonly used to make body kits, namely fiberglass, polyurethane, or commonly called plastic, and carbon. Each material has advantages and disadvantages. Fiber is the most popular material because this material is cheap and quite easy to make. However, fiber has a weakness in terms of strength and flexibility, where if a not too hard impact hits it, there is a risk of damage. Plastic is also quite popularly used to make body kits, but this material has two variants, namely ordinary plastic and ABS (acrylonitrile butadiene styrene). The difference between the two is quite significant, both in terms of quality and price. Whereas ordinary plastic is more easily broken and rigid, while ABS plastic is not easily broken and flexible. These differences make ABS plastic priced quite expensive. Even most body kits made of this material are not produced locally but are imported. In contrast, carbon is a material that is rarely used because the price is very expensive. This material has advantages in terms of strength and is much lighter weight than the two materials above. This ability will certainly affect the performance of the vehicle[1].

II. Material And Methods

The materials used in the manufacture of biocomposite specimens of pandan fiber mats are as follows:

a) Pandan Fiber Mat

Pandan mats that have been soaked in NaOH solution, then the outer layer is shaved, and the fibers are visible.

b) Epoxy Resin and Hardener

The binder of pandan mat fiber biocomposite material that has become fiber is mixed directly with Epoxy Resin and Hardener resin.

c) NaOH

NaOH is used to separate pandan mat fibers.

d) Grease

Grease is a material used to lubricate the mold so that the resin does not stick to the mold.

The equipment used in the study of biocomposite pandan fiber mats, as follows:

Impact Test Tool

This tool is used to measure the strength value of the specimen to be tested as for the specifications of the impact test equipment as follows:

Table 1 Specifications of impact test equipment

Tool Name	Charpy Impact Testing Machine
Brand	Torsee
Capacity	30 kg-m
Pendulum weight (m)	25,68 kg
Hammer Sleeve Length (R)	0,649 m

Figure 2 Impact Test Tool

Study Design:

1. Specimen Preparation

The thorny pandan leaves are obtained from community residential areas by taking the third and fourth lowest leaves to be quite old. The leaves are then cut along about 80 cm according to the length of the tub bucket that will be used. Before soaking in the tub bucket, the fiber is washed clean. After washing, the fiber is put into a tub bucket filled with alkaline water (NaOH) for five days. The fiber is then removed, shaved, and cleaned again to separate the fiber from the gum. The next stage is neutralization, by soaking the fiber in freshwater for 3 hours, after which the fiber is rinsed with clean water. In the last stage, the fiber is then aerated to dry slowly so that a balanced drying occurs between the inside and the outside, and fine cracks on the fiber's surface can be avoided.

2. Percentage Comparison of Composite Making Mix

The percentage comparison of making impact test specimens using materials made from a mixture of epoxy resin and hardener, pandan fiber which then forms a material whose composition is varied. In the manufacture of specimens three times replication so that from the resulting variations, the impact test specimens obtained were nine specimens. The comparison of the mixture of specimens used can be seen in the table below:

Table 2 Percentage of Impact Test Specimen Mixture

No	Fiber Orientation	Pandan Fiber Mat %	Resin (A) + Hardener (B) (Mix A:B / 2:1) %
1	0˚,45˚,*R°	5 %	95 %
2	0˚,45˚,*R°	15 %	85 %
3	0˚,45˚,*R°	25 %	75 %

*R= Random

3. Impact Test Specimen Standard

Impact testing was carried out on a mixture of pandan mat fiber with epoxy resin and hardener, the composite material to be tested was first made into a specimen. Impact testing aims to determine the strength of the material by providing energy slowly until the composite material breaks. The shape of the fracture and the direction of the fiber that affects the Impact Test is carried out by referring to the standard for making specimens according to the JIS Z 2202 standard.

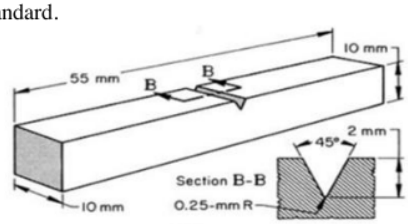


Figure 3 JIS Z 2202 . Specimen Size

Study Location: This is research based on biocomposite material engineering carried out in the mechanical engineering master's study program at the Sriwijaya University, Palembang, South Sumatra, Indonesia.
Study Duration: November 2020 to November 2021.
Sample size: 9 specimens.
Sample size calculation: The sample size was estimated based on the design orientation of the pandan mat fiber, namely 0°, 45°, *Random°, and the composition of the resin + Hardener matrix ratio with the pandan mat fiber reinforcement (Matrix: 95%, 85%, 75%. Fiber: 5%, 15 %, 25%) based on the highest values of fracture strength and ductility of the biocomposite material specimens.

Subjects & selection method: The study was taken from the test results with the highest value of 9 specimens based on the fracture strength and ductility value of the pandan fiber biocomposite material specimen with the impact testing method of the standard Charpy method of the JIS Z 2202 specimen.

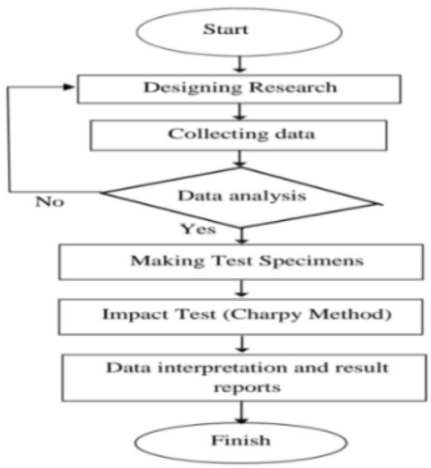
Inclusion criteria:

1. Fibrous fracture, which involves shifting the crystalline plane within a ductile biocomposite material (ductile). A dimple-shaped fibrous fracture surface characterizes it.
2. Granular/crystalline fracture, this event is produced by the cleavage mechanism in brittle specimens.
3. Mixed fractures (fibrous and granular) are a combination of the two types of fractures above.

Exclusion criteria:

1. Brittle fracture of the specimen
2. There is a void or air trapped in the specimen during printing
3. The union between the resin matrix and the fiber reinforcement is not solid

Procedure methodology:



III. Result

This section analyzes and discusses the research data, especially the parameters that affect the optimization of the mechanical properties (impact strength) of the mixed material of Pandan Mat Fiber (SPT) and Epoxy Resin (RE), which will be applied as a material for making motorcycle body kits.

Table 3 Fiber Composite Specimen Data [Matrix + Fiber (MF)]

NO	Composition				Orientation Fiber (°)	Total Weight Specimen (gr)	Amount (pcs)	Code Specimen
	Matrix A:B / 2:1	Weight (gr)	Fiber	Fiber Weight (gr)				
1	95 %	8,17	5 %	0,43	0	8,6	1	MF-01
2					45	8,6	1	MF-02
3					*R	8,6	1	MF-03
4	85 %	7,31	15 %	1,29	0	8,6	1	MF-04
5					45	8,6	1	MF-05
6					*R	8,6	1	MF-06
7	75 %	6,45	25 %	2,15	0	8,6	1	MF-07
8					45	8,6	1	MF-08
9					*R	8,6	1	MF-09

Impact Test Results

The process of testing this specimen was carried out as many as nine specimens with a mixture ratio and fiber direction using an impact testing process on pandan mat fiber composite materials, and epoxy resin can be seen in the table below with the results of sample testing used JIS Z 2202 as follows:

Table 4. Specimen test results

NO	Composition		Orientation Fiber (°)	Code Specimen	Corner Before (α)	Corner After (β)	Power Broken (KJ)	Tenacity (KJ/m²)
	Matrix A:B/2:1	Fiber						
1	95 %	5 %	0	MF-01	45	43	399	4,98
2			45	MF-02	45	43	399	4,98
3			*R	MF-03	45	43	399	4,98
4	85 %	15 %	0	MF-04	45	41	783	9,78
5			45	MF-05	45	42	599	7,48
6			*R	MF-06	45	42	599	7,48
7	75 %	25 %	0	MF-07	45	43	399	4,98
8			45	MF-08	45	43	399	4,98
9			*R	MF-09	45	44	199	2,48

Data Analysis and Macro Structure Fault

1. Broken Power

From the table, the results of the calculation of the data above can be explained in the form of a graph below:

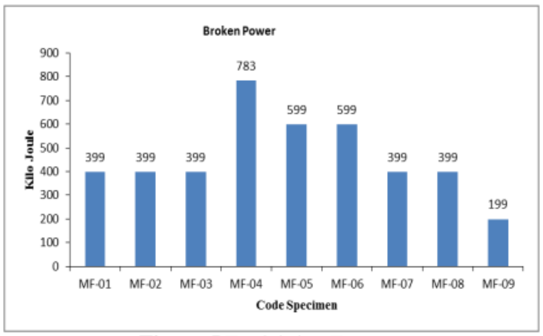


Figure 5 Explaining Fracture

From the graph above, it can be explained that the specimen with the code MF-04 with a composition of 85% resin + hardener with a mixture ratio (Mix A: B) 2:1 and 15% pandan mat fiber, the highest value of fracture strength was obtained from the impact test of 783 KJ (kilojoules). With specimen code MF-05 with a composition of 85% resin + hardener with a mixture ratio (Mix A: B) of 2:1 and 15% pandan mat fiber and MF-06 with a composition of 85% resin + hardener with a mixed ratio (Mix A: B) 2:1 and 15% pandan mat fiber obtained a moderate value of fracture strength from the impact test results of 599 KJ. With specimen code MF-01, MF-02, MF-03 with a composition of 95% resin + hardener with a mixture ratio (Mix A: B) of 2:1 and 5% pandan mat fiber and MF-07, MF-08 with a composition of 75 % resin + hardener with a mixture ratio (Mix A: B) 2:1 and 25% pandan mat fiber obtained a value below moderate fracture strength from the impact test results of 399 KJ. With the code specimen MF-09 with a composition of 85% resin + hardener with a mixture ratio (Mix A: B) 2:1 and 15% pandan mat fiber, the lowest fracture strength value was obtained from the impact test results of 199 KJ.

2. Tenacity

From the table the results of the calculation of the data above can be explained in the form of a graph below:

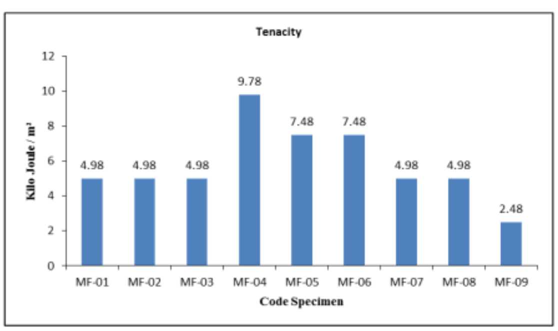


Figure 6 Explaining Tenacity

From the graph above, it can be explained that the specimen with the code MF-04 with a composition of 85% resin + hardener with a mixture ratio (Mix A:B) of 2:1 and 15% pandan fiber mat, the highest value of ductility from the impact test was 9.78 KJ. /m^2 (Kilo Joule/meter2). With specimen code MF-05 with a composition of 85% resin + hardener with a mixture ratio (Mix A:B) of 2:1 and 15% pandan mat fiber and MF-06 with a composition of 85% resin + hardener with a mixed ratio (Mix A:B) 2:1 and 15% pandan mat fiber obtained a moderate value of tenacity from the impact test results of 7.48 KJ/m^2. With specimen code MF-01, MF-02, MF-03 with a composition of 95% resin + hardener with a mixture ratio (Mix A:B) of 2:1 and 5% pandan fiber mat and MF-07, MF-08 with a composition of 75 % resin + hardener with a mixture ratio (Mix A:B) 2:1 and 25% pandan mat fiber obtained a value below moderate ductility from the impact test results of 4.98 KJ/m2. With code specimen MF-09 with a composition of 85% resin + hardener with a mixture ratio (Mix A:B) of 2:1 and 15% pandan fiber, the lowest ductility value from the impact test results is 2.48 KJ/m^2.

Macro Structural Fault Analysis

From the results of the impact testing that has been carried out, it can be explained that the analysis of the fracture form of the macro-structure of the specimen in the form of direct physical observation while the results of the analysis are summarized in the table below:

Table 5 Analysis of Macro Structural Faults

SPECIMEN CODE:	**MF-01**	**FIBER ORIENTATION 0°**
COMPOSITE MATERIAL COMPOSITION		
Matrix A:B/2:1		**Fiber**
95 %		**5 %**
		
Fault Analysis:		
The picture shows the surface and cross-sectional conditions of the composite with a variation of a mixture of 95% Resin + Hardener with a composition ratio of 2:1 and 5% Pandan Mat Fiber. Where the bond between the fiber and the matrix is not perfect, the results that occur cause the fiber to be separated from the matrix. Fiber pull-out occurs when it gets a load from the outside. This shows the pattern of inline, even, and shiny fractures are brittle fractures.		
SPECIMEN CODE:	**MF-02**	**FIBER ORIENTATION 45°**
COMPOSITE MATERIAL COMPOSITION		
Matrix A:B/2:1		**Fiber**
95 %		**5 %**
		
Fault Analysis:		
The picture shows the surface and cross-sectional conditions of the composite with a variation of a mixture of 95% Resin + Hardener with a composition ratio of 2:1 and 5% Pandan Mat Fiber. This shows a ductile fracture type because the image has a rough surface and has ductile fracture characteristics,		
SPECIMEN CODE:	**MF-03**	**FIBER ORIENTATION *R°**
COMPOSITE MATERIAL COMPOSITION		
Matrix A:B/2:1		**Fiber**
95 %		**5 %**
		
Fault Analysis:		
The picture shows the surface and cross-sectional conditions of the composite with a variation of a mixture of 95% Resin + Hardener with a composition ratio of 2:1 and 5% Pandan Mat Fiber. Where the bond between the fiber and the matrix is not perfect, the results that occur cause the fiber to be separated from the matrix. Fiber pull-out occurs when it gets a load from the outside. This shows the pattern of inline, even, and shiny fractures is a brittle fracture.		
SPECIMEN CODE:	**MF-04**	**FIBER ORIENTATION 0°**
COMPOSITE MATERIAL COMPOSITION		
Matrix A:B/2:1		**Fiber**
85 %		**15 %**
		
Fault Analysis:		

The picture shows the surface and cross-sectional conditions of the composite with a mixture variation of 85% Resin + Hardener with a composition ratio of 2:1 and 15% Pandan Mat Fiber. This shows that it has a ductile fracture type because the image has a rough surface as has the characteristics of a ductile fracture,		
SPECIMEN CODE:	**MF-05**	**FIBER ORIENTATION 45°**
COMPOSITE MATERIAL COMPOSITION		
Matrix A:B/2:1		**Fiber**
85 %		**15 %**
		
Fault Analysis:		
The picture shows the surface and cross-sectional conditions of the composite with a mixture variation of 85% Resin + Hardener with a composition ratio of 2:1 and 15% Pandan Mat Fiber. It shows that it has a ductile fracture type because the image has a rough surface and the characteristics of a ductile fracture.		
SPECIMEN CODE:	**MF-06**	**FIBER ORIENTATION *R°**
COMPOSITE MATERIAL COMPOSITION		
Matrix A:B/2:1		**Fiber**
85 %		**15 %**
		
Fault Analysis:		
The picture shows the surface and cross-sectional conditions of the composite with a mixture variation of 85% Resin + Hardener with a composition ratio of 2:1 and 15% Pandan Mat Fiber. Shows that it has a ductile fracture type because the image has a rough surface as has the characteristics of a ductile fracture.		
SPECIMEN CODE:	**MF-07**	**FIBER ORIENTATION 0°**
COMPOSITE MATERIAL COMPOSITION		
Matrix A:B/2:1		**Fiber**
75 %		**25 %**
		
Fault Analysis:		
The picture shows the surface and cross-sectional conditions of the composite with a variation of a mixture of 75% resin + hardener with a composition ratio of 2:1 and 25% pandan mat fiber. Where the bond between the fiber and the matrix is not perfect, the results that occur cause the fiber to be separated from the matrix. Fiber pull-out occurs when it gets a load from the outside. This shows the pattern of inline, even, and shiny fractures is a brittle fracture.		
SPECIMEN CODE:	**MF-08**	**FIBER ORIENTATION 45°**
COMPOSITE MATERIAL COMPOSITION		
Matrix A:B/2:1		**Fiber**
75 %		**25 %**
		
Fault Analysis:		
The picture shows the surface and cross-sectional conditions of the composite with a variation of a mixture of 75% resin + hardener with a composition ratio of 2:1 and 25% pandan mat fiber. It can be seen where the bond between the fiber and the matrix is not perfect. The results that occur cause the fiber to be separated from the matrix. Fiber pull-out occurs when it gets a load from the outside. This shows a ductile fracture type because the image has a rough surface and has ductile fracture characteristics.		
SPECIMEN CODE:	**MF-09**	**FIBER ORIENTATION *R°**
COMPOSITE MATERIAL COMPOSITION		
Matrix A:B/2:1		**Fiber**
75 %		**25 %**

		
Fault Analysis:		
The picture shows the surface and cross-sectional conditions of the composite with a variation of a mixture of 75% resin + hardener with a composition ratio of 2:1 and 25% pandan mat fiber. This shows that it has a ductile fracture type because the picture has a rough surface as has the characteristics of ductile fracture, where the bond between the fiber and the matrix is not perfect, the results that occur cause the fiber to be separated from the matrix, fiber pull out occurs when getting a load from the outside.		

IV. Discussion

It can be taken from the discussion above that the results of the impact test research in previous studies were carried out by (Masdani dan Dharta, 2019). Researching on the potential development of agarwood fiber-reinforced composites as a replacement material for fiberglass in the manufacture of car dashboards, the results obtained from impact testing that the highest impact strength occurred at 50% fiber volume fraction, which was 64,626 kJ/m^2. The results from previous studies that for the manufacture of car dashboard products, the impact strength of the car dashboard, which has a high impact ABS plastic material, is 13.48 kJ/m^2, so that the results of the research in terms of impact testing meet the standards of car dashboards[3].

In research conducted by (Samlawi et al., 2018), it was found that all mass fraction compositions had a percentage increase in length above the percentage of the comparison material, the composition of the mass fraction of 50%:50% resulted in the highest impact energy value of 198.75 Joule/cm^2, a composite material of fiber (Arenga pinnata) with a mass fraction composition of 50%:50% feasible to be used as an alternative material for motorcycle body covers[5].

In this study using pandan mat fiber with a mixture of epoxy resin and hardener ratios, namely Mix A: B = 2:1, with fiber directions 0°, 45°, *R° and a composition of 95% R+H with 5% fiber. , 85 % R+H with 15 % fiber, 75 % R+H with 25 % varied fiber, the highest value of fracture strength was 783 KJ (Kilo Joule) and the highest value of ductility was 9.78 KJ/m² (Kilo Joule / m²) with fiber direction 0° and a composition of 85% R+H with 15% fiber. From this research, the specimen code MF-04 with fiber direction 0° and composition ratio of mixture 85% R+H Mix A:B=2:1,15% fiber, is feasible to be used as an alternative material for motorcycle body kits.

V. Conclusion

Based on research conducted on the effect of the impact strength of composite materials mixed with fiber-matched mats and epoxy resin for the application of making motorcycle body kits, the following conclusions were drawn: After doing research that pandan fiber mats can be used as an alternative material for the manufacture of motorcycle body kits. Because when testing the pandan mat fiber composite material, it turns out that the impact test results for the pandan mat fiber composite material have the highest fracture strength value of 783 kilo joules (KJ) and the highest ductility value of 9.78 Kilo Joule/meter2 (KJ/m^2) with the composition 85 % R+H (Mix A:B=2:1) and 15 % fiber, when compared to ABS material for a motorcycle body, it has a high impact of 13.48 kJ/m^2.

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