Automotive Experiences
Vol. 2 No. 2 (2019) pp. 59-66

Available online at http://journal.ummgl.ac.id/index.php/AutomotiveExperiences
p-ISSN: 2615-6202 e-ISSN: 2615-6636

Research Paper

The Role of Catalysts on Composites Properties: A Case Study on Motorcycle Body Cover

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doi: https://doi.org/10.31603/ae.v2i2.2731

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Published by Automotive Laboratory of Universitas Muhammadiyah Magelang collaboration with Association of Indonesian Vocational Educators (AIVE)

Article Info
Submitted:
16/07/2019
Revised:
31/07/2019
Accepted:
01/08/2019

Abstract

Today, modification on motorcycle body cover has become a new automotive business. The main components for modifying the motor body cover are glass fibre, resin and catalyst. Catalysts are substances that can accelerate reactions, the more catalyst composition, the less time it takes to react. Therefore, this study aims to determine the effect of variations in catalysts on composite properties. The test is carried out by giving the catalyst in 4 variations (2.5%, 5%, 10%, and 20%) to 157 BQTN resin. The specimen was tested using ASTM D-256 for impact/hardness, ASTM D-790 for bending, and ASTM D-638 for tensile strength. During this study, we found that the 2.5% catalyst give good results for impact, bending, tensile strength, and also modulus young.

Key words: Motorcycle cover body, Catalyst, Fiberglass, Resin

Abstrak

Saat ini, modifikasi *cover body* sepeda motor telah menjadi bisnis otomotif baru. Komponen utama untuk memodifikasi *cover body* motor adalah fiberglass, resin, dan katalis. Katalis adalah zat yang dapat mempercepat reaksi, semakin banyak komposisi katalis, semakin sedikit waktu yang dibutuhkan untuk bereaksi. Oleh karena itu, penelitian ini bertujuan untuk mengetahui pengaruh variasi katalis terhadap sifat komposit. Pengujian dilakukan dengan memberikan katalis dalam 4 variasi (2.5%, 5%, 10%, dan 20%) ke resin 157 BQTN. Spesimen ini diuji dengan ASTM D-256 untuk uji impact, ASTM D-790 untuk uji tekuk, dan ASTM D-638 untuk uji tarik. Selama penelitian ini, kami menemukan bahwa katalis 2.5% memberikan hasil yang baik untuk kekuatan impact, kekuatan tekuk, kekuatan tarik, dan juga modulus young.

Kata Kunci: *Cover body* sepeda motor, Katalis, Fiberglass, Resin

1. Introduction

In the past decade, lightweight but strong materials have become an important requirement in the automotive industry, which includes engine components, chassis, interior, body, and supporting components [1], [2]. Materials engineering developed from hardening, alloys, to composites, starting from small-scale trials [3] to large-scale production to meet industrial needs [4].

One of the essential materials for automotive (including for motorcycles body) is composites, a

Symbol

A	:	Cross sectional area (mm²)
b	:	Width (mm)
d	:	Thickness (mm)
E		Modulus elasticity (kg/mm²)
K	:	Impact value (J/mm²)
L	:	Distance between mounting (mm)
P	:	Max Load (N)
W	:	Energy (J)
ε	:	Strain (%)
σ_b	:	Bending Stress (MPa)
σ_u	:	Ultimate Stress (MPa)

material that is formed from a combination of two or more materials with different mechanical properties and produces a new material with different properties from its constituent material [5]. Cover body of the motorcycle is an example component made of a fiber composite. Today, there are many demands from consumers and motorcycle enthusiasts to modify their motorcycles as desired. The making of a cover body is relatively easy, which is formed from glass fiber, resin and catalyst.

The utilization of palm fiber (*arenga pinnata*) as a composite for the motorcycle body was tested by Samlawi [6] with important findings that the composite material of palm fiber with a composition of mass fractions of 50% : 50% is feasible to be used as an alternative material for motorcycle body cover. A similar study was carried out by Afandi [7] that palm fiber composites have almost all the key properties for the motorcycle body. However, parts made from this composite are actually 2 times heavier than the original parts.

In fact, even though natural materials are promising, they are at risk of adding weight to parts in total so we focus on fiberglass. In this study, we will test composites with variations in catalysts with volume fractions of 2.5%, 5%, 10% and 20% into resin to find out how much catalyst can affect the mechanical properties of these composites.

The main material used is Yukalac 157 BQTN resin (unsaturated polyester resin commonly used for the manufacture of various types of fiberglass), catalysts, and fiberglass. The catalyst variations are 2.5%, 5%, 10% and 20% of the resin. Specimens were tested with impact, bending, and tensile tests. Drying of specimens is carried out at ambient temperature (20 °C - 25 °C).

2. Literature Review

Composites are made by combining two or more materials to produce new materials while maintaining important properties of the original material [5], [8]. This unique combination provides significant advantages over original materials in a variety of structural applications. Composite fibers consist of fibers which are bound by interconnected matrices. Fiber composite consists of fiber as reinforcement and matrix (resin) as adhesive or binding material. Fiber is the main carrier of material load, where the matrix component transfers the load from fiber to others. Addition of fiber composition and number of fiber layers can increase the tensile strength of the material [9]. The illustration of the composite material is presented in **Figure 1**.

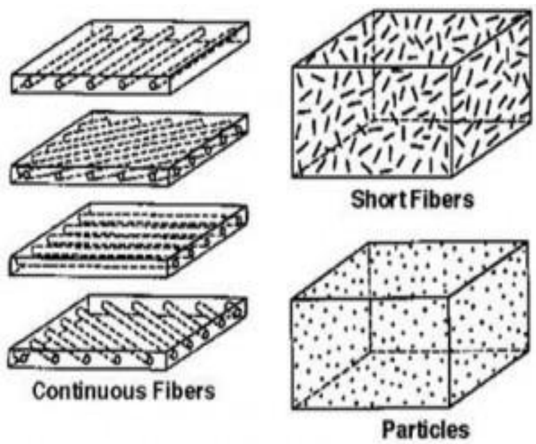

Figure 1. Illustration of composite material [10]

In manufacturing process, composites offer flexible solutions with many advantages because they can choose the right combination of fiber reinforcement and resin material to meet the application requirements and properties of the components. Catalysts are substances that work to accelerate chemical reactions. It can be organic, synthetic or metal. Increasing the composition of the catalyst can accelerate chemical reactions that occur in the material [11]. For small-scale applications and trials, catalysts can be purchased in small bottles, as shown in **Figure 2** (left).

During the reaction process, the energy known as activation energy is needed. Without the help of a catalyst, chemical reactions may never occur or require a long time. When a chemical reaction occurs, the catalyst itself does not change and is not part of the final result. The choice of catalyst is an important step to get optimal results in a reaction process [12].

Polyester resin is an unsaturated resin formed by the reaction of basic organic acids and polyhydric alcohol. Wall panels made from polyester resin reinforced with fiberglass called Fiberglass Reinforced Plastic (FRP) are usually used in restaurants, kitchens, toilets and other areas that require minimalist maintenance. Polyester resin is thermosetting, so excessive use of catalysts can cause a wildfire. Excessive catalysts can also cause the product to be easily damaged. An example of a resin is given in **Figure 2** (right).

Figure 2. Example of Catalist (left) and resin 157 BQTN (right)

Finally, fiberglass is also called glass reinforced plastic (GRP) or glass fiber reinforced plastic (GFRP) which made of a plastic matrix reinforced by fine glass fibers. It is also known as GFK (Germany: *Glas Faserverstärkter Kunststoff*). Fiberglass is a lightweight but strong material, although the strength is lower than carbon fiber and less rigid, the material is usually much more fragile. Fiberglass is really made of glass, similar to windows or drinking glasses in the kitchen. The glass is heated until it melts, then is forced through the prime hole, making glass filaments that are very thin and better measured in microns. For some applications, it is important for glass fibers to have fewer impurities, which involve additional steps in the manufacturing process. An example of fiberglass is given in **Figure 3**.

Figure 3. Fiberglass (MAT)

3. Material and Method

3.1. *Materials*

In this study, the volume of fiber used was 75% and the matrix was 25% for each specimen tested and tested at room temperature. While the composition of the catalyst is taken from the volume matrix with 4 variations of 2.5%, 5%, 10% and 20%.

3.2. *Testing Method*

First, the common tests of the physical characteristics of plastic materials is the impact test (Izod) by ASTM D 256 as the standard test method for determining the impact resistance of the Izod pendulum from plastic. Formula for impact value (K) is presented in Equation (1).

$$K = \frac{W}{A} \quad (1)$$

Where, K is impact value (J/mm^2), A is the cross sectional area of specimen (mm^2), and W is energy (J).

Bending test is a process of testing material by pressing to get results in the form of data about the bending strength of a material tested. The bending test has 2 types, namely 3 point bending and 4 point bending. In this study, we used 3-point testing. Formula of bending strength (σ_b) is presented in Equation (2).

$$\sigma_b = \frac{3 \times P \times L}{2 \times b \times d^2} \quad (2)$$

Where, σ_b is bending stress (MPa), P is the max load (N), L is distance between mounting (mm), b is material width (mm), and d is material thickness (mm).

Finally, tensile tests were carried out to measure the strength of the composites developed. Tensile strength is the maximum stress a material can hold when stretched before the material is broken (fracture). The formula for calculating the tensile strength is presented in Equation (3).

$$E = \frac{\sigma_u}{\varepsilon} \quad (3)$$

Where, E is modulus elasticity (kg/mm^2), σ_u is ultimate Stress (MPa), and ε is strain. The equipment for impact test, bending test, and tensile test are presented in **Figure 4**.

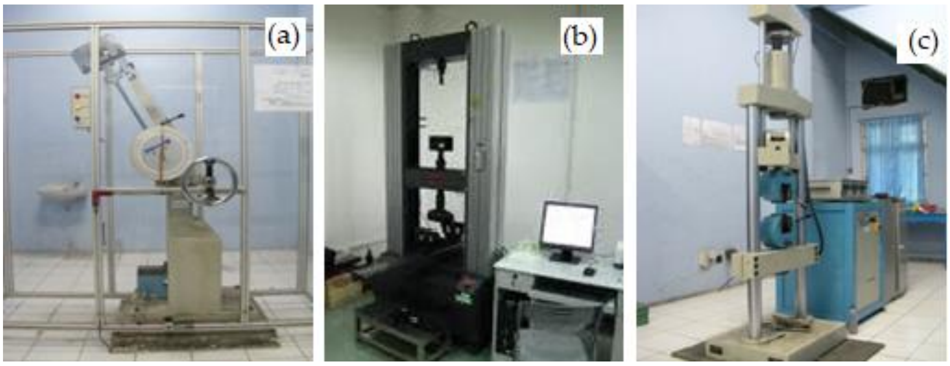

Figure 4. Test equipment: (a) impact test equipment, (b) bending test equipment, and (c) tensile test equipment

4. Result and Discussion

4.1. *Impact test*

Figure 5 shows the results of the impact test for specimens. Variation 1 and variation 2 show the highest hardness rate, which has the same value of 0.078 J/mm^2. Material hardness can be defined by the material's ability to absorb energy [13]. The harder the material, the more energy can absorb. So, variation 1 and 2 with 2.5% catalyst has better hardness and toughness than others.

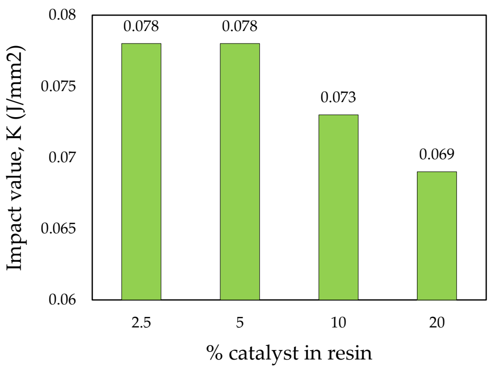

Figure 5. Impact to % catalyst in resin, complete data is given in Appendix 1 (**Table 1**)

4.2. *Bending test*

Variation 1 which is composed of catalyst 2.5% produces bending stress 199.86 MPa, catalyst 5% produces 105.61 MPa, catalyst 10% produces 78.18 MPa and variation 4 composed of catalyst 20% produces bending stress 52.5 MPa. The result of the bending test is presented in **Figure 6**, while the complete data of the test is presented in Appendix 1 (**Table 2**).

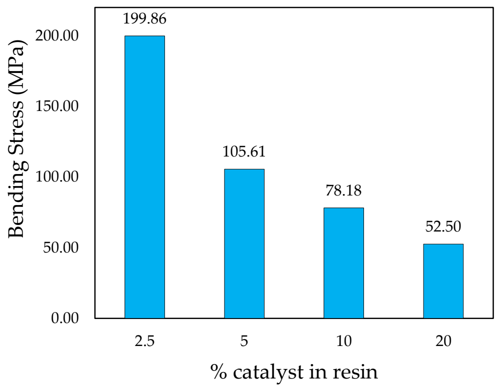

Figure 6. Bending stress to % catalyst in resin

4.3. *Tensile test*

Figure 7 shows that variation 1 has 60.75 MPa of ultimate stress and 81.15 kg/mm^2 of modulus elasticity, variation 2 has 76.64 MPa and 72.48 kg/mm^2, variation 3 has 72.22 MPa and 66.47 kg/mm^2, and variation 4 has 64.46 MPa and 72.44 kg/mm^2. Complete data of tensile test are provided in Appendix 1 (Table 3) and photographic view of specimen fracture is presented in Figure 8.

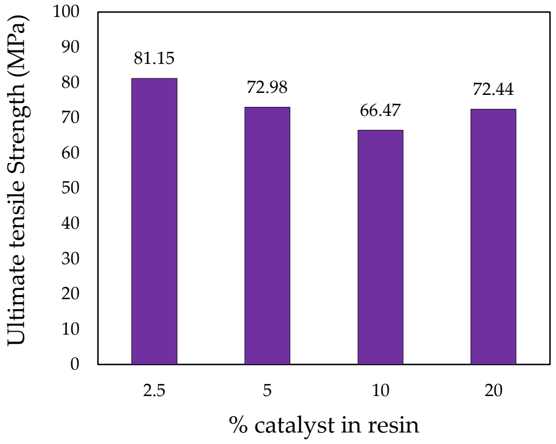

Figure 7. Ultimate tensile strength to % catalyst in resin

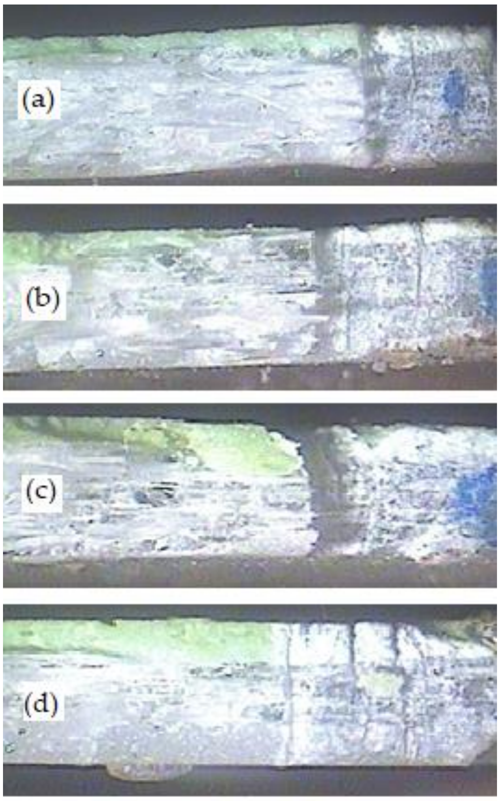

Figure 8. Photograph view of specimens fracture with catalyst composition: (a) 2.5% (b) 5% (c) 10% and (d) 20%.

From the test, it can be concluded that catalyst consumption of 2.5% (variation 1) has the best ability to withstand sudden forces. This condition fulfils the criteria because of the less catalyst in the resin, the more energy can be absorbed by the material. This is indicated by the highest impact value. The extension is meant by how resilient the material is, so variation 3 (catalyst 10%) is the most resilient with a strain value of 10.9%. Meanwhile, variation 1 is the most fragile, indicated by the highest modulus young and also has good hardness. Bending stress indicates how fragile the material is, so variation 1 has better properties.

Variation 1 has the slowest process which is around 72 minutes. This curing time has an effect on the molecule and increasing the temperature. By adding more catalysts makes the molecules move continuously and rearrange the resin molecules thereby reducing the holes (shafts) in the surface and inside the composite. After the cooling process, the molecules move more slowly so that this can increase characteristics or mechanical properties of a material. The strain to stress curve is presented in Figure 9.

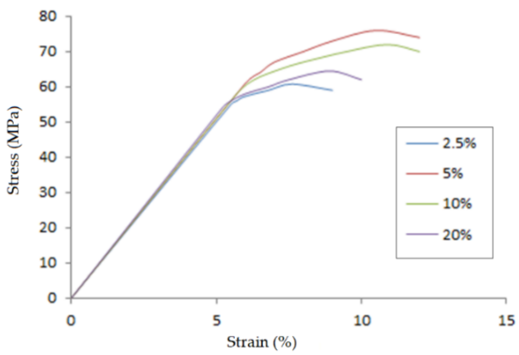

Figure 9. The strain to stress curve

5. Conclusion

The amount of catalyst can affect the physical properties of the material, where it functions to accelerate chemical reactions. So, fewer catalysts will need more time to complete the process and make the material harder. Whereas, the higher the catalyst composition provides a higher strain value so the material becomes more resilient but the addition of compositions exceeding 10% indicates a decrease in strain value.

The results of the impact test on the specimen showed catalyst variation of 2.5% having the highest impact value. The less of catalyst, the greater the strength of the material obtained. From the bending test, it is shown that the 2.5% catalyst has the highest bending stress. So that the less the catalyst composition, the more flexible the material and able to withstand the load. Whereas, in the tensile test, the material with 5% catalyst has the highest ultimate stress. The strain is the number of extensions which means ductile. So, all specimens that have passed the minimum strain value (5%) can be called ductile. According to the test, it can be concluded that variation 1 has better characteristics of hardness, toughness, even though it has the lowest extension value. So, the different catalyst composition have characteristics in the manufacture. During this study, we know that the physical properties of a material can be manipulated in many ways, and this is one way to do that (the ratio of catalysts in resin).

In typical application on motorcycle body cover, several factors need to be considered such as the selection of reinforcing materials, binding materials, the composition of materials, and manufacturing methods. The hard, tough, and resilient composite are expected to be formed by taking into account these factors so that in making a composite for motorcycle cover body can produce a good appearance and has good mechanical properties.

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Appendix 1. Data

Table 1. Impact test data

No.	Catalyst (%)	α (°)	W_1 (J)	β (°)	W_2 (J)	A (mm^2)	K (J/mm^2)
1	2.5	30	21	28.75	1.7	22.1	0.077
2	2.5	30	21	28.5	1.75	22.1	0.079
3	2.5	30	21	28.5	1.7	22.1	0.077
						Average	0.078
No.	**Catalyst (%)**	**α (°)**	**W_1 (J)**	**β (°)**	**W_2 (J)**	**A (mm^2)**	**K (J/mm^2)**
1	5	30	21	29	1.4	17.66	0.079
2	5	30	21	29	1.35	17.7	0.076
3	5	30	21	28.5	1.35	17.6	0.077
						Average	0.078
No.	**Catalyst (%)**	**α (°)**	**W_1 (J)**	**β (°)**	**W_2 (J)**	**A (mm^2)**	**K (J/mm^2)**
1	10	30	21	29	1.4	19.65	0.071
2	10	30	21	29	1.4	19.6	0.071
3	10	30	21	29	1.45	19.6	0.074
						Average	0.073
No.	**Catalyst (%)**	**α (°)**	**W_1 (J)**	**β (°)**	**W_2 (J)**	**A (mm^2)**	**K (J/mm^2)**
1	20	30	21	29	1.4	20.29	0.069
2	20	30	21	29	1.4	20.31	0.069
3	20	30	21	29	1.4	20.28	0.069
						Average	0.069

Table 2. Bending test data

No.	Catalyst (%)	Width (mm)	Thick (mm)	σ_b (MPa)	P_{max} (N)
1	2.5	13.26	1.48	198.31	4.83
2	2.5	13.21	1.46	203.28	4.8
3	2.5	13.28	1.48	198	4.83
			Average	199.86	4.82
No.	**Catalyst (%)**	**Width (mm)**	**Thick (mm)**	**σ_b (MPa)**	**P_{max} (N)**
1	5	14.38	1.6	104.31	5.65
2	5	13.98	1.62	103.71	5.6
3	5	14.42	1.56	108.82	5.62
			Average	105.61	5.62
No.	**Catalyst (%)**	**Width (mm)**	**Thick (mm)**	**σ_b (MPa)**	**P_{max} (N)**
1	10	13.66	1.86	71.1	5.85
2	10	13.71	1.7	84.82	5.85
3	10	13. 80	1.76	78.62	5.85
			Average	78.18	5.85
No.	**Catalyst (%)**	**Width (mm)**	**Thick (mm)**	**σ_b (MPa)**	**P_{max} (N)**
1	20	13.32	2.07	50.46	5.68
2	20	13.51	1.98	54.37	5.68
3	20	13. 40	2.02	52.67	5.68
			Average	52.5	5.68

Appendix 1 (continued)

Table 3. Tensile test data

No.	Catalyst (%)	σ_u (MPa)	ε (%)	E (kg/mm²)
1	2.5	61.05	7.6	80.33
2	2.5	61.12	7.1	86.08
3	2.5	60.09	7.8	77.04
	Average	60.75	7.5	81.15
No.	**Catalyst (%)**	**σ_u (MPa)**	**ε (%)**	**E (kg/mm²)**
1	5	76.63	10.5	72.98
2	5	77.17	10.6	72.8
3	5	76.11	10.4	73.18
	Average	76.64	10.5	72.98
No.	**Catalyst (%)**	**σ_u (MPa)**	**ε (%)**	**E (kg/mm²)**
1	10	72.1	10.9	66.15
2	10	72.54	10.8	67.17
3	10	72.03	10.9	66.08
	Average	72.22	10.9	66.47
No.	**Catalyst (%)**	**σ_u (MPa)**	**ε (%)**	**E (kg/mm²)**
1	20	64.25	8.8	73.01
2	20	64.03	9	71.14
3	20	65.11	8.9	73.16
	Average	64.46	8.9	72.44