Impact Strength Analysis Of Ramie Fiber And Woven Ramie Composite

Zulkifli Djafar[1], Ilyas Renreng[2] ,Miftahul Jannah[3]

Abstract-- Natural fibers are one of the reinforcing materials used to strengthen the composite. One of the natural fiber that is being developed is ramie fibers. This study will analyze the effect of the layer number of woven ramie and the type of ramie fiber weight on the impact strength. The number of plies that used for woven ramie are 1, 2 and 3 plies, while the type of ramie fiber weight are type A, B and C. The test results shown that the plies number of woven ramie and the type of ramie fiber's weight are affecting the impact strength of the composite. From this research, the highest impact strength is found in woven ramie composite with 3 layers of plies with the average impact strength value 11.37 ± 0.92 kJ/m^2, while for ramie fiber the highest impact strength is found in type C weight with average impact strength is 12.3 ± 12.30 kJ/m^2.

Keywords: Natural Fiber Composite, Ramie Fiber, Woven Ramie, Impact Strength.

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1 INTRODUCTION

Composites are materials formed from a combination of two or more materials through a non-homogeneous mixing process, in which the mechanical properties of each material are different.[1]. Composite material is a multi-phase system consisted of matrix material and reinforcing material. One aspect to consider in obtaining new materials is the use of materials derived from plants or organic fibers. [2]. In the last decades, the needs of natural material utilization for engineering application is increasingly draw attention among researchers due to the environmental awareness . This is resulting in increasing number of natural fiber utilization for composite materials with both, thermosetting and thermoplastic matrices. [3] The advantages of using natural fiber for composite materials is because of the composite materials have lighter weight than metals, corrosion resistance, environmentally friendly and easy to be designed in the direction of loading [4] [5].

Ramie *(Boehmeria Nivea)* is one of the oldest types of fiber that has been used for thousands of years that has an average height of 1.8 meters, with the features of dark green leaves, heart-shaped, and wrinkled leaves. The lower part of the leaf is covered with white hair, and has a rod with a thickness of 1.2 cm. [6]

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Pure ramie can be spun into fine yarn, either dry or wet. When there is static electricity, the fiber can stick to the clothes. Pure Ramie can produce beautiful weaving threads and Ramie's yarn is initially stiff, but, like most ramie, will soften with age. Rami increases the luster and durability of cotton fibers. Ramie also integrates with the sutras. Ramie grows well in areas with good rainfall and warm climates and grows best in fertile soils or sandy soils. The ramie fiber as a composite reinforcement is processed by cutting the stem of the ramie plant, then through the process of decorticated, degummed and alkaline treatment. The ramie fiber is then spun into yarn and then processed through a Weaving Machine to produce woven ramie.

Polymer matrix composite material is the one that uses organic polymer as matrix and fiber as reinforcement. Strength and modulus of fiber are much higher than the matrix material normally. This makes fibers the main load-bearing component. However, there must be a matrix material with good adhesion properties to firmly bond fibers together. At the same time, the matrix material can serve to uniformly distribute the applied load, and transfer the loads to fiber. In addition, some properties of composite materials mainly depend on the characteristics of the matrix material. As a result, in composite materials, the performance of fiber, matrix and the interface between them directly impact on the performance of composite materials. Although the composite materials of application in the aerospace industry take only a very small share, most of the materials it adopted are advanced composite materials, representing the most advanced technology of composite materials industry.

In addition the composite materials for the aerospace,, especially glass fiber composite materials get a wider range of applications in the other economic areas as a result of advantages of their price and performance. They play an important role in the promotion of scientific and technological progress and the development of national economy. In United States, 1,171,000 tons of fiber composites were produced in 1991, of which 324,000 tons were used in transport, 205,000 tons in construction, 169,000 tons in shipbuilding, 163,000 tons in corrosion equipment, 110,000 tons in electronic appliances, 70,000 tons in business equipment, 75,000 tons in daily necessities, only 18,000 tons in aerospace military, and 37,000 tons in others.[7].

2 LITERATURE

2.1 Composite

Composite is an engineered material comprising two or more substances in which the properties of each material differ from one another, both chemical and physical, and remain separate in the final product. Composite materials have a lot of keungulan, including low-strength type of higher strength, corrosion resistance and has a cheaper assembly cost. [8]

In composites there is a material called as matrix and reinforcement material. Matrix materials can generally be metals, polymers, ceramics, carbon. The matrix in the composite serves to distribute the load into all composite reinforcing materials. The nature of the matrix is usually ductile. The reinforcing material in the composite serves to withstand the load received by the composite material. The properties of reinforcement materials are usually rigid and tough. The most commonly used reinforcement materials are carbon fiber, glass fiber, ceramic. Natural fibers as the type of fiber that has the advantages began to be applied as a reinforcing material in polymer composites. [9]

2.2 Natural Fiber

There are many fibers, which are widely used are synthetic fibers. Natural fiber is a type of fiber derived from natural materials both derived from animals and plants. The strength of the composite is highly dependent on the fiber used to strengthen the composite, since the stress applied to the composite initially received by the matrix will be passed to the fiber, so the fiber will withstand the load to the maximum load. Therefore, the fiber must have higher tensile stress and elastic modulus than the composite matrix. [10]

Some properties of fiber that will greatly affect the mechanical strength of a composite material, that properties such as the type of fiber, fiber placement, Fiber length, and diameter of fiber. Based on the placement, the fiber can be divided into 3 groups, including One Dimensional Reinforcement that has a strength in the direction of fiber axis, Two Dimensional Reinforcement which has two forces in either direction or each direction of fiber orientation and Three dimensional reinforcement having higher isotropic properties compared to other types. Long fibers are stronger than short fibers. Therefore, the fiber length and diameter are very influential on the strength and composite modulus. Long fibers or composite fibers are more efficient at placing than short fibers. [11]

2.3 Ramie (Boehmeria Nivea)

Rami or Boehmeria Nivea is one of the oldest types of fiber that has been used for thousands of years that has an average height of 1.8 meters, with the features of dark green leaves, heart-shaped, and wrinkled leaves. The lower part of the leaf is covered with white hair, and has a rod with a thickness of 1.2 cm. [6]

Figure 1. Ramie Plant

The Ramie fiber is white and shiny and looks like silk, but has no stretch and elasticity. Very absorbent, more than cotton, ramie fabric breathe well and make comfortable clothes for warm and humid summer. Ramie is one of the strongest and strongest natural fibers even when wet. Like the linen, it will break if folded repeatedly in the same place, so avoid pressing the sharp fold or folding the ramie cloth. The hemp cloth does not shrink and is resistant to bacteria and fungi, which means it does not rot easily. [12]

Rami is more difficult to process than other fibers because the fibers are united by gummy resins that do not readily decompose. The retting process commonly used for hemp. Processing should start as soon as possible after the stem is cut off, otherwise the resin hardens and becomes difficult to remove. [13]

2.4 Matrix

The composite matrix consists of various kinds and types, including polymer matrix, ceramic matrix, metal matrix. Matrix with polymer material is a matrix widely used for composite manufacture. In the metal matrix generally use titanium, magnesium and alloys. Composites with metal matrices have resistance to high temperatures reaching 1250^{0}C. In addition to having a high temperature resistance, the metal matrix also has a higher strength and stiffness than the polymer, but also has a deficiency in density that tends to be heavier than polymers, so the metal matrix can not be a reference material matrix which can be a lightweight material alternative . [14]

Epoxy resin is one of the matrix options in composite making. The use of Epoxy Resins is also widely applied to casting, coating, used for electrical insulators, paint blends and adhesive mixtures. Epoxy resins also have excellent wear resistance and shock resistance. [15]

Epoxy resins are made of two different chemical components that act as resins and act as hardener. Most common epoxy resins produced from the reaction between epichlorohydrin and bisphenol-A.

The hardener consists of a polyamine monomer, for example Triethylenetetramine (Teta). When these compounds are mixed together, the amine group reacts with the epoxide group to form a covalent bond. Each NH group can react with the epoxide group, so the resulting polymer is highly cross linked, and thus rigid and strong. The polymerization process is called "curing", and can be controlled through temperature, the choice of resin and hardener compounds, and the ratio of said compounds; the process can take minutes to hours. Some formulations benefit from heating during healing, while others only require time, and ambient temperature. [16]

2.5 Impact Strength Of Composite

Composite impact strengths depend on fiber, matrix, fiber / matrix interface conditions and test conditions. [17] Impact Strength is one of the important criteria for knowing the greediness of a material. The impact test is carried out using rapid loading. Impact resistance is typically measured by either the notched or charred Charpy or Izod method. The load is swung from a certain height to hit the specimen, which is then measured energy absorbed by its fracture. Special composite material with natural fiber reinforcement material, this test refers to the standard specified in ASTM D5942 with the following calculation method [18]:

$$L_p = \frac{g_n}{4\pi^2} \times T^2 \tag{1}$$

Where g_n is Acceleration Standard fell free, with value 9.81 m / s^2, T is the Period, from once full swing (to and from) is determined from at least 50 consecutive and unbroken swings (known 1 part accuracy in 2000). The swing angle should be less than 5 ° on each side of the center.

The distance terms between the rotation axis and the collision point in the center of the specimen shall be within 61% of the pendulum length, Lp. The length of the pendulum, Lp, in meters (m), can be determined experimentally from the period of small amplitude oscillations in the pendulum.

In this study using charpy impact test by using the sample without the notch. In ASTM D5942, the standard used to calculate the charpy impact force on the composite panel without the use of a notch, the following formula :

$$a_{cU} = \frac{W}{h \times b} \times 10^3 \tag{2}$$

Where a_{cU} = charpy impact strength without a notch; W = Energy absorbed to break up test specimens (Joule); h= Thick of specimen(mm).; And b = Specimen width (mm).

3 RESEARCH METODE.

3.1 Research Design.

Preparation of impact specimens was adjusted to ASTM D5942-96, Charpy impact strength of unnotched specimens, Unnotched specimens of Type 1 is used. There are no specified specimen sizes. The only important parameter is the ratio of the span, L, to the specimen dimension in the direction of blow (see Table 1). Specimens are usually tested in the normal direction (see Fig. 2). [19]

Table 1. Specimen Types, Dimensions, and Span [18]

Specimen TypeB	Length,C l	Width,C b	Thickness,C h	Span, L
1	80 ± 2	10.0 ± 0.2	4.0 ± 0.2	62 + 0.50
2	25 h	10 or 15F	3D	20h
3	(11 or 13)h			(6 or 8)h

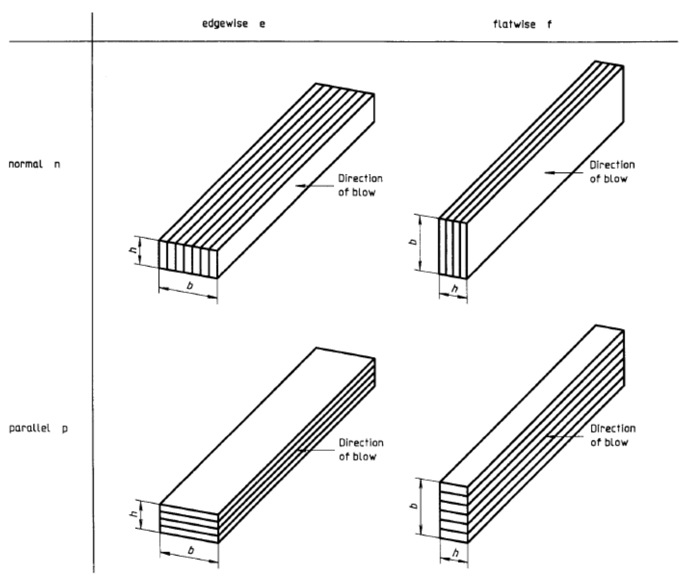

Figure 2. The Scheme of Designations Describing the Direction of Blow

3.2 Tool and Materials

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The equipment used in this research is Digital scales to measure the weight of the woven ramie so we can determine the weight of the ramie fibers and then compare the impact strength of those both reinforcement materials. Digital oven to post-curring the composite. Hydraulic Press Machine to press the composite mold. While the material used in this research is Woven Ramie, Ramie Fiber, Eposchon A and B for Matrix.

Figure 3. Mixing Epoxy Resin and Hardener with Ramie fiber Reinforcement in to the Mold

In this study variation of woven ramie plies that used are 1, 2, and 3 plies, while the variation for ramie fiber are the weight type A, B and C.

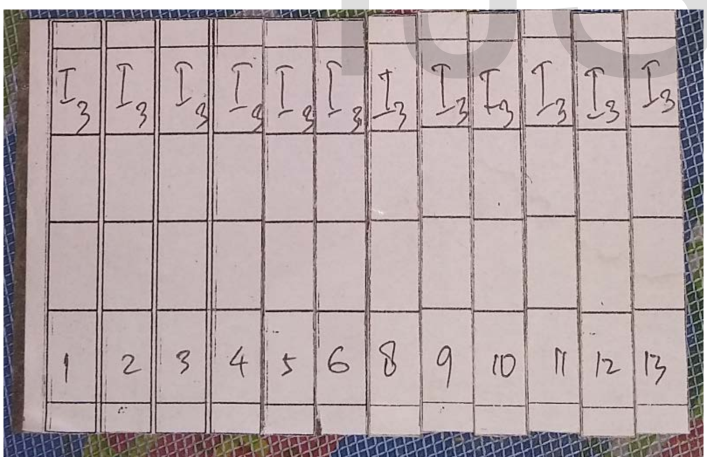

Figure 4. Impact Specimen With The Specimens Labels

Fig. 4 is an image of a specified impact test specimen based on a predetermined mold size in ASTM D5942-96. Each plies number or the tipe of ramie fiber weight have 5 specimens that tested to get the average number of the impact strength of the composite.

4 RESULTS AND DISCUSSION

4.1 Result

4.1.1 Impact Strength of Woven Ramie Composite

The result of composite impact testing based on ASTM D 5942 - 96 obtained the amount of energy absorbed by the specimen until broken, then from the data we will get the value of impact strength of each ramie fiber and woven ramie specimens.

The result of the impact test for woven ramie are shown in Table 2, where IT1 = the average impact strength of 1 ply of woven ramie, IT2 = the average impact strength of 2 plies of woven ramie, IT3 = the average impact strength of 3 plies of woven ramie.

Table 2. Impact Test Results for Woven Ramie Composite

Specimens Number	Average of Fractural Energy (J)	Average of Impact Strength (kJ/m²)
IT1	0.28	7.03±0.56
IT2	0.40	10.44±1.10
IT3	0.43	11.37±0.92

In Table 2 shown that with the increasing number of plies in the woven ramie composite tends to also increase the impact strength of a composite. For more details, it can be noted in Fig. 5 that shown the relations between ramie woven plies numbers with impact strength of composites.

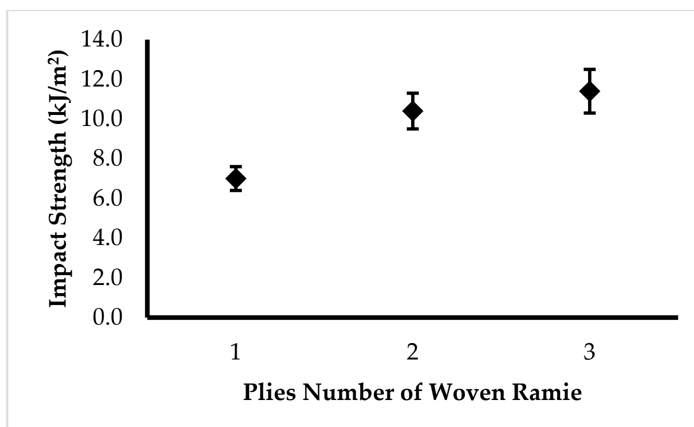

Figure 5. The Relations Between the Plies Number of Woven Ramie Composite to the Impact Strength

Figure 5 shows the relations between the plies number of woven ramie with impact strength, where the results shows that the highest impact strength of the woven ramie composite is present in the 3 plies with impact strength value is 11.37 ± 0.92 kJ / m². While the lowest impact strength available in 1 ply of woven ramie composite with impact value is 7.03 kJ / m².

4.1.2 Impact Strength of Ramie Fiber Composite

The result of the impact test for ramie fiber are shown in Table 3, where IS1 = the average impact strength of A-weight type of ramie fiber composite, IS2 = the average impact strength of B-weight type of ramie fiber composite, IS3 = the average impact strength of C-weight type of ramie fiber composite.

Table 3. Impact Test Results for Ramie Fiber Composite

Specimens Number	Average of Fractural Energy (J)	Average of Impact Strength (kJ/m²)
A	0.36	10.2±10.16
B	0.43	11.2±11.24
C	0.45	12.3±12.30

In Table 3 shown that with the increasing the weight tipe of the ramie fiber composite tends to also increase the impact strength of a composite. For more details, it can be noted in Fig. 6 that shown the relations between ramie fiber's weight type with impact strength of composites.

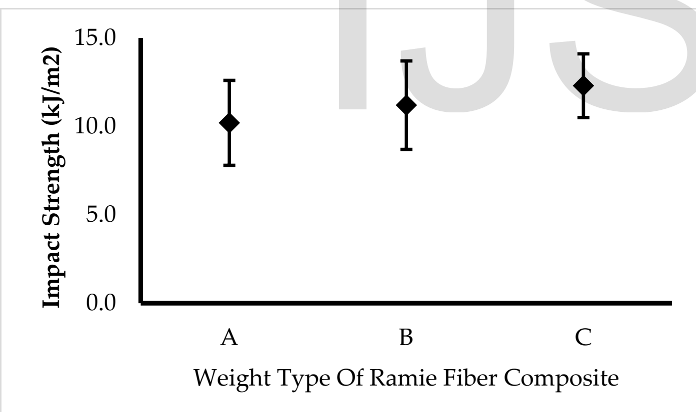

Figure 6. The Relations Between the Weight Type of Ramie Fiber Composite to the Impact Strength

Figure 6 shows the relations between the weight type of ramie fiber with impact strength, where the results shows that the highest impact strength of ramie fiber composite is present in the C-weight type of ramie fiber composite with impact strength value is 12.3±12.30 kJ / m², while the lowest impact strength available on A-weight type of ramie fiber with impact value is 10.2±10.16 kJ / m².

4.2 Discusion

The results of the above study are consistent with the results of research conducted by E.V. González, et al, 2010, with the research title "Effects of ply clustering in laminated composite plates under low-velocity impact loading". The researcher presents a study about the effect of clustering of ply amounts on polymer-based laminate composites with drop-weight impact loading methods. By increasing the number of plies, stiffness changes during loading become more progressive and smoother when compared to laminate with thin film. This result gives difficulties in detecting Fd value values for laminate with thick layers. It has been shown that the more ply, elongation will increase over time. This result is related to the fact that greater delamination is created when the number of interfaces available for delamination is reduced. Therefore, it can be concluded that grouping of ply counts results in lower damage resistance to composite structures. However, the damage tolerance, measured using the residual press load is not affected by the increase in the thickness of the coating, since all types of laminates presented have shown the same value of the peak pressure load on each impact energy.

Conclusion

Based on the results of research that has been done in impact test analysis of composite ramie fiber and woven ramie *(Boehmeria Nivea)* by using epoxy resin and hardener as the matrix, it can be concluded that the impact specimens which have the highest impact strength of woven ramie composites are specimens with the number of woven plies of 3 plies with an average Impact strength value is 11.37±0.92 kJ/m², while for Ramie fibers the highest impact strength is found on the fiber weight of C type specimens with the average value of impact strength is 12.3±12.30 kJ/m².

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