Composite Nfrp (Natural Fiber Reinforced Plastic) Cane Dregs Fiber With 5% NaOH Delignification Treatment Using Compression Molding Techniques In Wind Turbine Blades Applications

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Research Article

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Abstract Indonesia's energy needs are increasing from time to time, this is due to the increasing population growth. The use of conventional energy derived from fossils still dominates as a source of energy used. Wind energy in Indonesia has considerable potential to be exploited. One of the important components in a wind turbine is the blade or blade. The knife serves to catch the wind which is then forwarded to the generator. In making composites for this study using the compression molding method, this method is carried out using hydraulics as a press, the fibers that have been mixed with resin are inserted into the mold cavity, then pressing and heating. Then from the test results, it was found that for the absorption energy, the optimal value of impact strength, tensile strength and tensile elastic modulus on the composite specimen with delignification treatment for 2 hours, where the absorbed energy was obtained 1.8 J and the impact strength value was 0.040 J / mm², the value of tensile strength obtained is 7,700 MPa and the modulus of elasticity is 1287.03 MPa.

Key words: Blade, composite, compression, epoxy, variation.

Introduction

Indonesia's energy needs are increasing over time this is due to the increasing population growth. The use of conventional energy derived from fossils still dominates as a source of energy used. Wind energy in Indonesia has a large enough potential to be exploited. The National Energy General Plan (RUEN) lists 60,647.0 MW for wind speeds of 4 meters per second or more (Attachment to Presidential Regulation Number 22 of 2017). To be able to take advantage of existing wind energy, an energy converter is needed that can convert wind kinetic energy into electrical energy. One example of a tool that can be used to convert this energy is wind turbines, an offshore area that has the potential to have large wind energy (Kurniawan D., 2016).

One of the important components in a wind turbine is a blade or blade. The function of the blades is to catch the wind which is then forwarded to the generator. As a wind-facing component, wooden slats often have problems with their surface. One of them is due to the collision of particles and dust carried by the wind (Sagol, 2013). The particles and dust carried by the wind that accumulate continuously erode the surface of the blade. Dalili stated in his research that debris from insects hitting the tip of the blade surface alone can result in a reduction in turbine power output by up to 50%.

Materials with certain characteristics such as strength, ductility, and other mechanical properties as needed are highly sought after. For this reason, composite materials are used to make wind turbine blades that are lightweight yet strong and stiff. The composites chosen are those that come from natural fibers which are a material that can replace synthetic materials and other material products in terms of their lighter weight and a more environmentally friendly production process in terms of energy (Ho et al, 2012).

Bagasse fiber is one of the alternative natural fiber materials in the manufacture of composites, in general bagasse fiber is used for animal feed, bagasse has strong fibers with soft Parenchyma tissue and bagasse was chosen because of its abundance and strength in nature, and good durability. In making composites for this study using the compression molding method, this method is carried out by using hydraulic as a press, the fibers that have been mixed with resin are inserted into the mold cavity, then pressing and heating.

In previous researchers Sujito (2014), has used bagasse fiber as a composite constituent material, where the maximum tensile strength value at 40% fiber volume fraction was 28.27 MPa and the impact test results obtained maximum impact strength at 40% fiber volume fraction of 972.8 kJ / m². Researcher Nugroho (2005) observed the content of bagasse which contains lignin, pentosan and cellulose. The content of these substances can affect the mechanical properties of the composite material. So that to remove lignin and pentosan substances, an alkaline
treatment process is carried out, one of which is the delignification process (KOH, LiOH, NaOH) of bagasse fiber to improve the properties of the fiber, reduce lignin and separate the contaminants contained in the fiber. The length of time soaking the alkaline solution also affects the strength of the resulting composite.

Researchers Wahono (2008) also strengthened the soaking time with the alkaline solution, by giving NaOH treatment for 2, 4, 6 and 8 hours, the best composite with NaOH treatment on the fiber for 2 hours. The longer the fiber is immersed in NaOH, it can remove the lignin layer and other impurities, it can result in a stronger interface bond between the fiber and resin but it can result in the fiber becoming more brittle because more lignin and other impurities are lost in the fiber, so the ability to withstand loads decreases.

So the focus in this study was to determine the effect of delignification of 5% NaOH on the composite material with a volume fraction ratio of 60% epoxy matrix and 40% bagasse fiber. The variables in this study were no treatment of bagasse fiber, delignification treatment with 5% NaOH for 2, 4, 6 and 8 hours for bagasse fiber, each with a fiber length of 3-5 cm. The tests carried out are tensile testing (ASTM D-638) and impact resistance testing (ASTM D-6110). The future goal in this study is to determine the maximum tensile strength and impact strength of epoxy composite materials so that later it is known whether or not this material is applied in the world industry.

Materials and methods

This study studied the mechanical properties and observations of the effect of alkaline treatment with immersion time on bagasse natural fillers and epoxy matrices. At the initial stage of this research was carried out in several stages, the stage of the experimental material preparation stage, the fiber treatment stage with immersion time, the composite manufacturing stage, the testing stage, and the data processing stage.

In the preparation stage of the experimental materials, the fibers were stripped and washed from the dregs of the sugarcane plant and continued with the fiber drying process. In the variation stage of fiber treatment with immersion time, four types of variables were carried out, namely, the first without treatment of bagasse fiber with a fiber length of 3-5 cm, the second delignification treatment with 5% NaOH for 1 hour against bagasse fiber with a fiber length of 3-5 cm, the three delignification treatments with 5% NaOH for 2 hours against bagasse fibers with a fiber length of 3-5 cm and the last variable was delignification treatment with 5% NaOH for 3 hours on bagasse fibers with a fiber length of 3-5 cm, and continued with the process of drying the fibers with sunlight to dry, followed by the process of making composites. At the stage of making composites, the compression molding method is carried out with a volume fraction ratio of 40% bagasse fiber and 60% epoxy matrix according to the mole fraction calculation that has been done, then mixed with orientation. random fiber.

In the testing phase, the mechanical properties of the sample were tested in the form of tensile testing according to ASTM D-638 standards and impact resistance testing according to ASTM D-6110 standards. At the testing data processing stage, the interpretation of the test results data and the results of the analysis on the microstructure interface is carried out to determine the optimal chemical treatment of bagasse fiber as a natural powder composite.

Table 1. Variables and Variations of Sugarcane Dregs Composite Sample Testing

<table>
<thead>
<tr>
<th>Code</th>
<th>Sample</th>
<th>Specimen</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Without Treatment</td>
<td>Pull: √</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Impact: √</td>
</tr>
<tr>
<td>B</td>
<td>Delignification Treatment of 5% NaOH</td>
<td>Pull: √</td>
</tr>
<tr>
<td></td>
<td>for 1 hour</td>
<td>Impact: √</td>
</tr>
<tr>
<td>C</td>
<td>Delignification Treatment of 5% NaOH</td>
<td>Pull: √</td>
</tr>
<tr>
<td></td>
<td>for 2 hour</td>
<td>Impact: √</td>
</tr>
<tr>
<td>D</td>
<td>Delignification Treatment of 5% NaOH</td>
<td>Pull: √</td>
</tr>
<tr>
<td></td>
<td>for 3 hour</td>
<td>Impact: √</td>
</tr>
</tbody>
</table>

Table 2. Composition of sugarcane bagasse fiber composite test sample
Sample Mold in Volume (cm$^3$) Fiber in Volume (cm$^3$) Fiber Mass (gram)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Mold in Volume</th>
<th>Fiber in Volume</th>
<th>Fiber Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particle Board</td>
<td>348.1</td>
<td>208.86</td>
<td>174.05</td>
</tr>
</tbody>
</table>

**Figure 1.** Composite sample testing standards: (a) tensile ASTM D 638 and (b) impact ASTM D 6110-4

**Results and discussion**

**Impact test results**

From the tests carried out, the value of the absorption energy or fracture energy and the value of the impact strength on the composite with a volume fraction of 40% bagasse fiber and 60% epoxy matrix belonging to each specimen treatment is shown in Figure 3 and Figure 4. The graph shows an upward trend and down the same. Statistical analysis on the test results uses a standard deviation, this sequences data that has a considerable distance from one another. The test data shows that the composite without alkaline treatment has an impact strength value of 0.0312 Joule which is smaller than the epoxy matrix impact test sample with a value of 0.0345 Joule. While the test sample with 5% NaOH immersion for 1 hour had higher absorption energy and impact strength values of 1.566 Joules and 0.034 J/mm$^2$ respectively compared to the epoxy matrix impact sample and the composite impact test sample without treatment. This shows that the epoxy-bagasse sugarcane fiber composite with alkalization treatment within 1 hour has an effect on the increase in strength and ductility. However, an interesting thing happened to the composite sample with 5% NaOH immersion for 2 hours which had the highest value both in absorbing energy and impact strength, namely 1.8 Joules and 0.04 J/mm$^2$. While the test sample with 5% NaOH immersion for 3 hours decreased with a value of 1.116 Joules to absorb energy and 0.024 J/mm$^2$ for impact strength even lower than the composite test sample with 5% NaOH immersion for 1 hour.
Figure 2. Graph of average impact energy absorption of control samples (epoxy matrix) and various types of treatment with a volume fraction of 40% waste sugar cane fiber and 60% epoxy matrix.

Figure 3. Graph of average impact strength of control samples (epoxy matrix) and various types of treatment with a volume fraction of 40% waste sugar cane fiber and 60% epoxy matrix.

Tensile test results

From the results of the tensile test of the composite test sample, a graph of the relationship between force load and length increase is obtained. Force load data and length gain can be processed and graphed for stress, strain, and
modulus of elasticity. The results of the tensile test of the composite test sample were taken the average of each experiment on the control sample (epoxy matrix) and the variation without treatment and 5% alkaline NaOH treatment for 1 hour, 2 hours, and 3 hours as in Figure 4, Figure 5., and Figure 6. It was found that the epoxy matrix test sample had a low strain of 1,234. On the other hand, this value is almost the same in the untreated composite tensile test specimen which has a strain of 1,411. Based on Figure 5, the composite tensile test specimen by immersing 5% NaOH for 1 hour decreased its strain to 0.796. And a decrease in strain occurs until the composite tensile specimen is immersed in 5% NaOH for 2 hours with a value of 0.062. Furthermore, there was an increase in the composite sample by immersing 5% NaOH for 3 hours, namely 1,021. This allows 2 h of immersion to have the lowest reduction or brittleness compared to other composite specimens. The decrease in strain value in composites with 5% alkaline NaOH treatment for 2 hours is supported by the theory that plant fibers generally have higher stiffness and strength when given the effect of the extraction method. In this case, the type of plant fibers is bagasse with the alkalization extraction method.

![Average Tensile Strength Graph](image)

**Figure 4.** Graph of Average Tensile Strength of Tensile Test Specimens
Figure 5. Graph of average strain of control samples (epoxy matrix) and various types of treatment with a volume fraction of 40% waste sugar cane fiber and 60% epoxy matrix.

From the resumes of tensile strength and shown in Figure 5, all samples are directly proportional to the modulus of elasticity shown in Figure 7. It can be analyzed that the variation with 5% alkaline NaOH treatment and bagasse immersion time made the composite stronger and had an increased immersion limit of 2 hours. The results of the tensile test by immersion for 2 hours produced the highest tensile strength and modulus of elasticity of 7.7 MPa and 1287.03 MPa, respectively. The decrease in tensile strength and modulus of elasticity occurred at 3 hours immersion. This reasoning is also supported by the results of the impact strength on the same sample, namely that immersion for 3 hours is no longer effective, which is most likely due to the dissolution of the cellulose element so that its strength begins to decrease. The increase in immersion time will cause the strength of the bagasse to decrease due to alkalization and the dissolution of cellulose which results in weakness or damage to the bagasse fiber composite.
Figure 6. Graph of average modulus of elasticity of control samples (epoxy matrix) and various types of treatment with a volume fraction of 40% waste sugar cane fiber and 60% epoxy matrix

Scanning Electron Microscope Observations

Figure 7. SEM Test Results with 50x Magnification of Untreated Composite Tensile Specimens

It can be seen that in this composite filled with bagasse fibers, a failure occurs which is dominated by the release of the bonds between the fibers and the matrix called fiber pull out and there are several voids. Although only a few voids are indicated, the presence of these voids triggers premature failure which eventually results in crack propagation in the composite due to voids between the matrix and the reinforced, where the matrix will always transfer the stress to the amplifier. When the composite receives a load, the stress area will move to the void area and cause the crack to appear, so that the composite will fail early.
The results of the Scanning Electron Microscope (SEM) test of composite tensile specimens with delignification treatment (NaOH 5% ) for 1 hour. Failures that occurred in this composite were found, namely fiber pull out, debonding and voids. Debonding that occurs in the fracture form of this tensile test states less than the untreated composite because the fiber absorbs more energy so that the interface between the bagasse fiber and the epoxy matrix is stronger than the untreated composite, this is related to more unification of bagasse fibers and the epoxy matrix. that happens and there are still voids which of course can affect the tensile strength of the composite with 5% alkaline NaOH treatment by soaking for 1 hour.

The results of the Scanning Electron Microscope (SEM) test of composite tensile specimens with delignification treatment (NaOH 5% ) for 2 hours. In this composite it is also seen that the voids that occur are less than the specimen or composite test object without treatment, 1 hour immersion treatment and 3 hours immersion treatment, so it is stated that the composite with alkaline treatment with 2 hours immersion has a density of interface bonds between fibers and good epoxy and makes the composite absorb more energy when it is pulled. Due to the high level of interface density between fibers and epoxy that occurs in composites with 5% alkaline NaOH treatment with immersion for 2 hours, making composites with 5% alkaline NaOH treatment by soaking for 2 hours 40% bagasse fiber and 60% epoxy matrix has The highest tensile strength value when compared to composites without 5% alkaline NaOH treatment,
composites with 5% alkaline NaOH treatment with immersion for 1 hour and composites with 5% alkaline NaOH treatment with immersion for 3 hours at a volume fraction of 40% bagasse fiber and 60% epoxy matrix.

**Figure 10.** SEM Test Results with 50x Magnification of Composite Tensile Specimens by Immersion for 3 Hours

The results of the Scanning Electron Microscope (SEM) test of composite tensile specimens with delignification treatment (NaOH 5%) for 3 hours. In this composite it was also seen that the voids that occurred were more than the specimens or composite test objects without treatment, 1 hour immersion treatment and 2 hours immersion treatment, so it was stated that the composite with alkaline treatment with 3 hours immersion had a density of interface bonds between fibers and epoxy is less good. The more voids contained in the composite, the lower the mechanical properties of the composite itself. Due to the low level of interface density between fibers and epoxy that occurs in composites with 5% alkaline NaOH treatment with immersion for 3 hours, making composites with 5% alkaline NaOH treatment by soaking for 1 hour 40% bagasse fiber and 60% epoxy matrix has the lowest tensile strength value when compared with composites without 5% alkaline NaOH treatment, composites with 5% alkaline NaOH treatment with immersion for 1 hour and composites with 5% alkaline NaOH treatment with immersion for 2 hours at a volume fraction of 40% bagasse fiber and 60% epoxy matrix.

**Application**

Blade or blades is a component that plays an important role in a windmill system. This component is a component that directly faces wind energy. Turbines have been produced with composite blades, made of steel spars, with an aluminum shell supported by rib wood. Turbines (three blades, 24 m rotor, 200 kW) war first wind energy success story: it has been running for 11 years without maintenance. After the 1970s, most wind turbines were produced with composite blades (Manwell et al, 2000) Thus, the relationship between the success of wind energy generation technology and the development and use of composite materials for turbine parts is evident from the first steps of wind energy utilization, whereas turbines first, built with steel blades, failed, the second, with composite blades, worked for many years. For that we need innovation related to the development of innovative materials for making wind turbine blades, namely composites.
The blades represent the most important composite-based part of a wind turbine, whose properties quite often determine the performance and life of the turbine. In fact, the rotor is the highest cost component of a wind turbine (Mohamed and Wetzel, 2006). However, the failure rate of wind turbine blades reached 20% in three years (Richardson, 2010), and this is definitely an exaggeration. Increasing the reliability and service life of wind blades is an important issue for wind turbine developers. The results of mechanical testing including tensile and impact testing as well as fractographic observations through SEM, concluded that bagasse composite with 2 hours delignification treatment is closer to being applied as a blade wind turbine.

Conclusion

The conclusions obtained in this study are. From each of the impact and tensile test results of bagasse fiber reinforced composites with epoxy matrices with various variations, it was found that for the absorbed energy, the value of impact strength, tensile strength and the optimal modulus of tensile elasticity were found in composite specimens with delignification treatment for 2 hours, where the energy absorbed is obtained 1.8 J and the value of the impact strength is obtained 0.040 J / mm², the value of tensile strength is obtained 7,700 MPa and the modulus of elasticity is obtained 1287.03 MPa.

Referensi


