Journal Mechanical Engineering (JME).
VOL 01, NO. 01, APRIL 2023

The Effect of Variation Percentage Alkalization (NaOH) On the Mechanical Properties Analysis and Water Absorption Behaviour in Biocomposite with Cassava Rubber Starch

Nevada. J. M. Nanulaitta
Mechanical Engineering Major in Ambon Polytechnic – Indonesia
Ir. M. Puttuhena Wailela Street, Rumah Tiga Village, Ambon City 97234
Maluku Province – Indonesia
rio_nevada@yahoo.co.id

Abstract

Composites made using natural ingredients namely sago fiber and cassava rubber starch as the matrix. This composite making is expected to get good bending strength, impact strength and water absorption rate. Composites are made using the hand lay-up method with a variation of the matrix and the variation of the volume fraction of sago pith fibers is 50%: 50% and 70%: 30% using NaOH liquid and distilled water in the alkali process with a percentage ratio of 0%, 5%, 10%, 15% and 20%. soaking time in NaOH liquid for 120 minutes.

The results of this study were found to be the best impact value on composites with 50%: 50% fiber volume variation with 15% alkaline NaOH liquid process, the highest value on the energy absorbed by the composite was 7.5479 (J) with an impact strength of 0.0755 (J/mm^2) at a variation of 70%: 30% the highest absorption energy is 5,7430 (J) while the impact strength is 0.0574 (J/ mm^2) at 15% NaOH liquid percentage.

The highest bending strength is 226.035 MPa at 50%: 50% volume fraction variation with 15% NaOH liquid percentage, 70%: 30% fiber volume fraction variation with the highest value 206,199 MPa at 15% NaOH liquid percentage. The best water absorption rate is at 8 , 82% that occurs in the variation of 50%: 50% fiber volume fraction with 15% percentage of the alkaline process NaOH and 9.16% in the variation of 70% fiber volume fraction: 30% fiber with 15% NaOH liquid in the alkalization process

Keywords : Sago Pith Fiber, Cassava Rubber Starch, NaOH, Hand Lay Up Method, Bending Strength, Impact Strength and Water Absorption Rate

Abstrak

Komposit dibuat dengan menggunakan bahan alami yaitu serat sagu dan pati karet singkong sebagai matriknya. Pembuatan komposit ini diharapkan mendapatkan kekuatan lentur, kekuatan impak dan tingkat penyerapan air yang baik. Komposit dibuat menggunakan metode hand layup dengan variasi matriks dan variasi fraksi volume serat empulur sagu yaitu 50% : 50% dan 70% : 30% menggunakan cairan NaOH dan akuades dalam proses alkali dengan rasio persentase 0%, 5%, 10%, 15% dan 20%. waktu perendaman dalam cairan NaOH selama 120 menit.

Hasil penelitian ini didapatkan nilai impak terbaik pada komposit dengan variasi volume serat 50%:50% dengan proses cair NaOH alkali 15%, nilai energi tertinggi yang diserap oleh komposit adalah 7,5479 (J) dengan impak. kekuatan 0,0755 (J/mm2) pada variasi 70% : 30% energi serapan tertinggi adalah 5,7430 (J) sedangkan kekuatan impak 0,0574 (J/mm2) pada persentase cairan NaOH 15%.

Kekuatan lentur tertinggi adalah 226,035 MPa pada variasi fraksi volume 50%:50% dengan persentase cairan NaOH 15%, variasi fraksi volume serat 70%:30% dengan nilai tertinggi 206,199 MPa pada persentase cairan NaOH 15%. Laju penyerapan air terbaik adalah pada 8 ,82% yang terjadi pada variasi 50%:50% fraksi volume serat dengan 15% persentase NaOH proses basa dan 9,16% pada variasi fraksi volume serat 70%:30% serat. dengan cairan NaOH 15% dalam proses alkalisasi

Kata kunci : Serat empulur sagu, Pati Karet Singkong, NaOH, Metode Hand Lay Up, Kekuatan Tekuk, Kekuatan Benturan dan Laju Penyerapan Air

1. Introduction

The need for materials causes the development of knowledge in the field of metallurgy to get new materials developing rapidly, one of which is a composite which is a substitution of metal. The advantages of composite materials are that they have good strength and rigidity, are lightweight, have low production costs, are resistant to corrosives and can be made according to needs. Various advantages possessed by composite materials from other materials make composite materials an alternative choice for humans as one of the materials used to respond to increasing human needs. The rapid development of composite material technology development so that the mechanical strength value of the composite can be adjusted by modifying the composites. This natural material with a relatively high silica content can be used as an adsorbent (Muhammad Fathurrahman et al, 2022)

The defines composite as a material that is formed from a combination of two or more forming materials through an inhomogeneous mixture, where the mechanical properties of each forming material are different (F. L. Matthews et al, 2000)

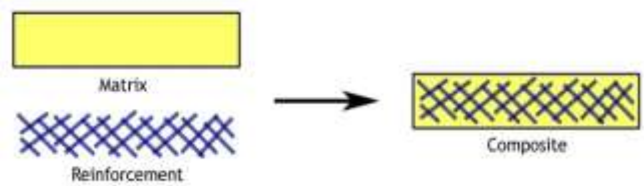

Fig. 1 Composite Material

Jacobs also explained that the placement of fibers and the direction of different fibers made the fiber reinforced composites differentiated into several sections, including: Continuous or uni-directional, Woven fiber composite, Discontinuous Fiber Composite. The longer the process of immersing the fiber in an alkaline solution, the lower the water absorption capacity of the composite. (Rita Desiasni et al, 2021). The matrix in the composite structure can come from polymeric materials, metals, or ceramics (Gibson, 1994). To increase the adhesion of the fiber, the rougher the surface of the fiber, the adhesive bonding will also increase and the mechanism of interlocking bonding can occur on two surfaces between the fiber and the matrix (Wang et al., 2005). In this bond the rough surface is able to cause more interlocking and the resulting more perfect Mechanical Bonding. The interface bond is perfect if the load or force applied to the amplifier is parallel to the Interface

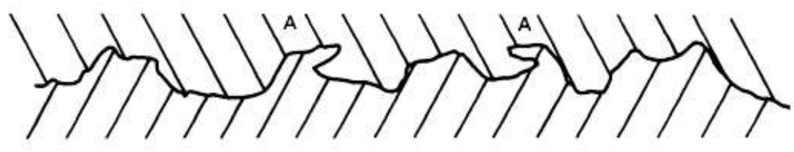

Fig. 2 Mechanical Bonding

in modifying the alkaline process proposed it will damage the hydrogen bonds and in this way will make the surface of the fiber more rough (Mohanty et al, 2005). The process of alkali in the fiber will remove a number of lignin, wax and oil on the surface of the fiber wall, resulting in depolymerization of cellulose. The alkalization process can reduce the hydrophilic properties of natural fibers where hydrophilic properties easily absorb moisture. Once natural fibers are exposed to moisture, hydrogen bonds will form between the hydroxyl groups of the cellulose molecule and water (Nevada. J. M. Nanulaitta et al., 2018)

From this research it is expected to know the effect of changes in the variation of the volume fraction of sago pith fibers and rubber cassava starch matrix and the percentage of alkalization (soaking process with NaOH liquid) on the mechanical properties and behavior of water absorption from the biocomposite sago pith fibers with rubber cassava starch.

2. Materials and Methods

2.1. Materials

Data collected in this study are data taken during experiments. The data taken is biocomposite with comparison of sago pith fiber (a) and rubber cassava matrix (b) are: 50% (a): 50% (b) and 30% (a): 70% (b). The liquid used to soak the fiber consists of the percentage of distilled water compared to 0%, 5%, 10%, 15% and 20% NaOH liquid (Alkalization).

Table 1.Properties Sago Pith

Fiber	Cellulose (%)	Hemicellulose (%)	Lignin (%)	Water Content (%)
Sago Pith	33	14	8.7	44.3

2.2. Fabrication of composites

Weighing of sago pith fibers and cassava rubber starch matrices in accordance with the desired volume fraction, Preparation of molds; The mold shape of the test specimen is in accordance with ASTM standards. then pour the matrix into a mold that has been placed and arranged in the sago pith fiber in accordance with the specified volume fraction is compacted, and this is made to form layers. Drying the composite in the oven with a temperature of 100 °C for 120 minutes, make observations on the composite whether there is no voids that occur by looking at the composite sheet. Its diameter is not more than 1 mm. Voids must not lump in one place (the radius of distance between voids allowed is 1 cm)

2.3. Bending Strength Testing

Bending testing is one of the mechanical properties testing of materials carried out on specimens of the material. Bending is the process of loading a material at a point in the middle of the material held on two supports. With this loading the material will deform with two opposing forces working at the same time. As the behavior of the material to the loading, all materials will experience a deformation (deformation) gradually from elastic to plastic until finally experiencing damage (broken). (ASTM Standard D 790 - 03)

2.4. Impact Strength Testing

In the impact test the measurement of energy absorbed to break the test object. The greater the energy absorbed, the lower the swing back from the pendulum. The fracture energy absorbed is expressed in Joules. The principle of this impact test is that if the test object is given a shock load, then the object will experience an energy absorption process resulting in plastic deformation that results in fracture. Impact test specimens were made according to ASTM D 256 standard. To determine the object's resistance to fracture, Charphy's impact testing method was used.'. A material is said to be tough if it has the ability to absorb large shock loads without cracking or deformation easily.

2.5. Water Absorption Testing

The testing process conforms to the ASTM E 96 standard, where the container is filled with distilled water. The specimen before being put into the container was weighed to find out the initial weight, after that it was put into the container with the specimen distance from the surface of the aquades of 0.25 inches. The container is closed, after that the container is left at room temperature for 24 hours. After 24 hours the container is opened, the specimen is removed then weighed to determine the final weight of the specimen, then calculate the percentage of water absorption rate in the specimen by comparing the weight before and after the process

3. Results and Discussions

3.1. Bending Strength Testing

From the calculation data of bending strength and bending strain can be shown the relationship between the percentage of NaOH vs Bending Strength in Fig 3 showed an increase in bending strength due to the increasing percentage of NaOH, this can be seen in the two variations of the fiber volume fraction, in the variation of the 50% fiber volume fraction: the highest 50% value was at the 15% NaOH percentage of 226.035 MPa while in the 70% fiber volume fraction variation : 30% are at 15% NaOH percentage of 206,119 MPa. The increase in the value of bending strength at 15% NaOH is caused by the increased levels of NaOH in the alkalization process resulting in better chemical reactions in removing lignin, wax, oil, hemicellulose compounds and impurities on the surface of the fiber so that the fiber becomes cleaner and the surface roughness of the fiber becomes better.

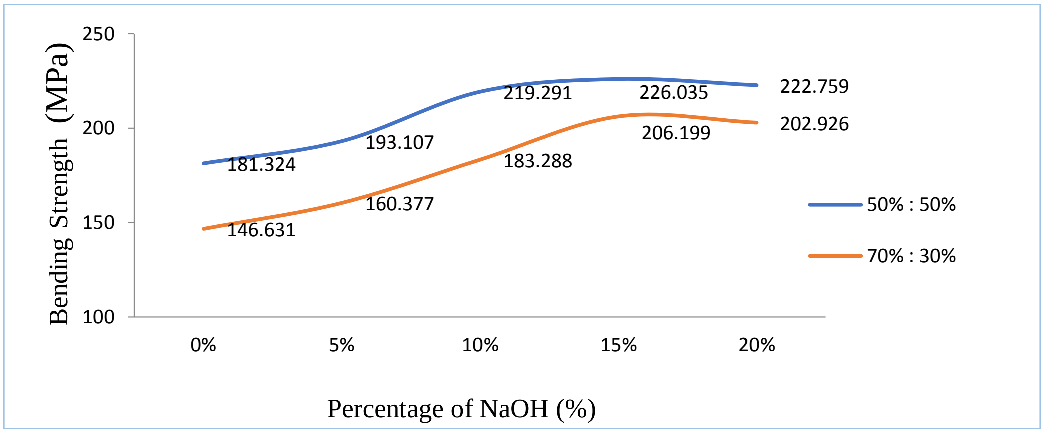

Fig. 3 Relationship between NaOH Percentage vs. Bending Strength

The introduction of clean and coarse fibers results in a better bonding interface between the fiber and the mantric so that the adhesion properties between the fiber and the matrix get better, this is very affective in the transfer and distribution of the load on the composite. Increasing the volume fraction of the fiber so that the bending strength is also increased due to the strength of the fiber which affects the strength of the composite. The bending test results can be seen in Figure 3. that the increased bending strength of the composite due to the pressure in the bending testing process received by the composite will be accepted by the matrix which automatically passes on to the fiber, the more fiber content the smaller each load received by each fiber so that the load received by the composite is greater.

3.2. Impact Strength Testing

The maximum impact strength is the percentage of 15% NaOH in composites with a variation of 50%: 50% volume fraction ie 0.0755 (J/mm^2) and the minimum percentage at 0% NaOH at 0.0133 (J/mm^2). Whereas in the composite volume variation fraction of 70%: 30% with a percentage of 15% NaOH the maximum impact strength is 0.0574 (J / mm2) and the minimum at the percentage of 0% NaOH at 0.0072 (J/mm^2), this can be seen at Figure 4

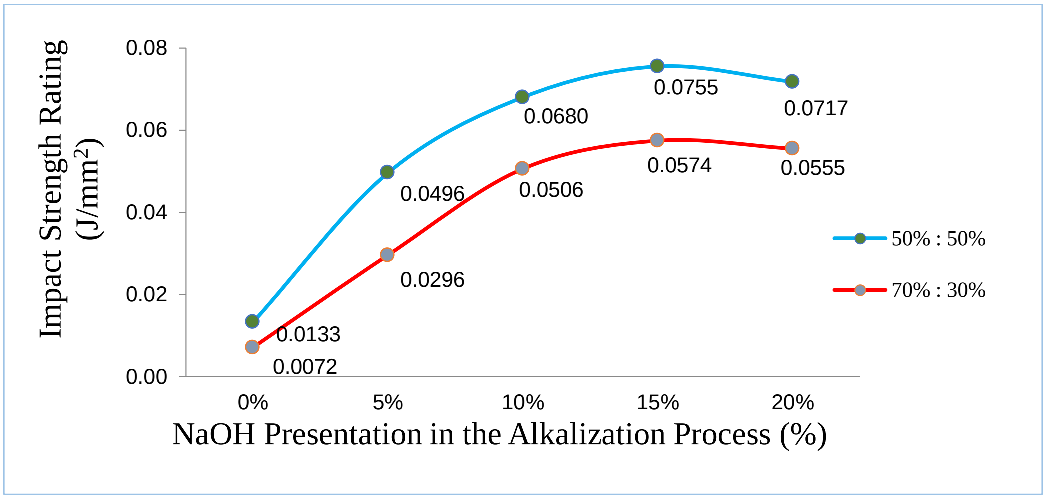

Fig. 4. Relationship between NaOH Percentage vs. Bending Strength

The impact strength value is seen increasing from the percentage of 0% NaOH to the percentage of 15% NaOH in both variations of the fiber volume fraction, this is due to the better bonding interface between the matrix and the fiber. Good interface bonding gives increased absorption energy and impact strength, the alkalization process reduces hydrophilic properties of the fiber by reducing lignin, cellulose and wax which are part of the chemical composition which decreases the bonding capacity between the fiber and the matrix. The increasing percentage of NaOH in the alkalization process, the better the surface condition of the fiber so that the bond between the fiber and the matrix is optimal.

The decrease in hydrophilic properties on the surface of the fiber results in a better interface bond between the fiber and the matrix. the two variations in fiber volume fraction. The impact energy absorption and impact strength values are seen to increase from the percentage of 0% NaOH to the percentage of 15% NaOH.

3.3. Water Absorption Testing

From Fig. 5. it is known that an increase in the maximum weight difference and maximum water absorption occurs in composites with a variation of 50%: 50% volume fraction is at the percentage of 0% NaOH with a difference in weight gain of 0.357 grams and the percentage of water absorption at 9.62%. While the minimum difference is in the percentage of NaOH 15% with a value of 0.328 grams, with a minimum percentage of water absorption of 8.82%

Whereas on composites with variations in the volume fraction of 70%: 30% the difference in maximum weight gain is in the percentage of 0% NaOH with a maximum difference of 0.392 grams with a percentage of water absorption of 10.54%. The minimum weight difference in the variation of this volume fraction is in the percentage of 15% NaOH with a difference of 0.340 grams, with a minimum percentage of water absorption of 9.16%.

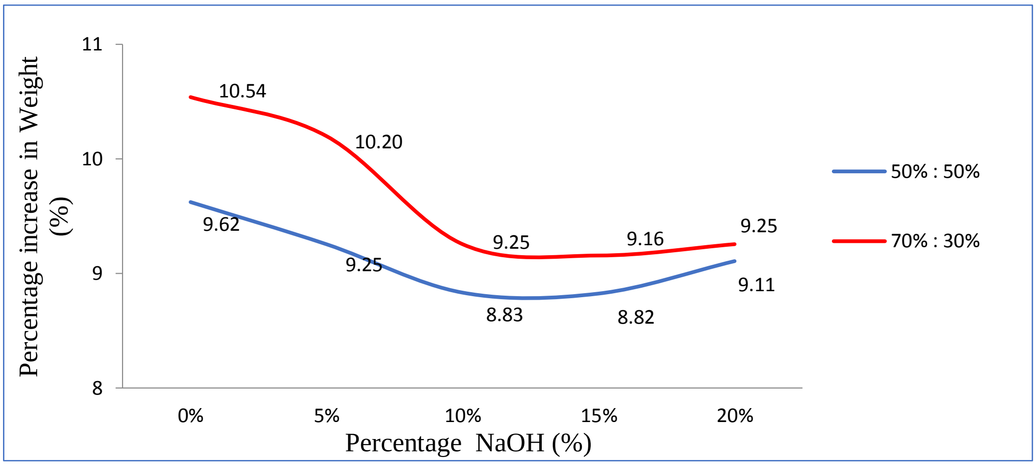

Fig. 5. Percentage of Increase in Weight vs NaOH Percentage

The decrease in water absorption in composites is influenced by the modification of the surface of the fiber in the alkalization process, the alkalization process can reduce the hydrophilic nature of natural fibers. The small weight gain of the composite results in a small water absorption rate also on the composite and that is better for the composite. This can be seen in Figure 5 the smallest percentage increase in composite weight was in the alkalization process with a percentage of NaOH of 15% in each variation of the fiber volume fraction.

4. Conclusions

in both variations of the volume fraction, After the fiber has been immersed with NaOH solution, the fiber tends to decrease in chemical composition. The greater the percentage of NaOH in the same immersion process results in the strength of the composite increasing and vice versa the smaller the percentage of NaOH the smaller the strength of the composite.

At the maximum percentage of 15% NaOH, the maximum increase after the increase in NaOH percentage, the strength of the composite gradually decreases, this is because the higher the percentage of NaOH, the more damaged the fiber condition.

5. References

F. L. Matthews. et al., 2000. *Composite Materials : Enggineering and Science*. Woodhead Publishing Limited, Cambridge England

Gibson, 1994., *Principle Of Composite Material Mechanics. New York : Mc Graw Hill,Inc.*

Jacob, James. A and Kilduf, Thomas F, 1994., *Engineering Materials Tecnology : Structure,Processing, Properties & Selection. Prentice-Hall International, Inc. London*

Mohanty.A.K, et al . 2005., *Natural Fiber, Biopolimers, and Biocomposites.* By CRC Press Taylor & Francis Group.

Muhammad Fathurrahman et al., 2022., *Sintesis dan Karakterisasi Komposit Eugenol-Silika Gel dari Abu Tongkol Jagung serta Analisis Antibakteri dan Daya Serap terhadap Air*, ALCHEMY Jurnal Penelitian Kimia, Vol. 18(1) 2022, 10-18

Nevada JM Nanulaitta et al., 2018. *Pengaruh Fraksi Volume Serat Empulur Sagu (Metroxylon Sp) Dan Presentase Alkali Terhadap Pengujian Impak Serta Absorpsi Air Pada Komposit Berserat Sagu*. Jurnal Rekayasa Mesin Vol.9, No.3, 163-168, 2018

Rita Desiasni. et al., 2021. *Pengaruh Volume Limbah Serbuk Kayu Jati (Tectona Grandis) Terhadap Daya Serap Air Pada Komposit Partikel Dengan Matriks Epoksi*, Jurnal Tambora Vol. 5 No.2 Juli 2021

Wang, W, Sain, M, Copper, P.A. 2005. *Study of moisture absorption in natural fiber plastic composites*, composites science and technology pages 379-386