Jurnal Media Mesin, Vol. 24 No. 1
Printed ISSN: 1411-4348
Online ISSN: 2541-4577

THE EFFECT OF WEBBING ANGLE ORIENTATION ON PHYSICAL AND MECHANICAL PROPERTIES OF BOEHMERIA NIVEA FIBER COMPOSITES

Fajar Perdana Nurrullah
Department of Mechanical Engineering
Institut Teknologi Sumatera
Email: Fajar.nurullah@ms.itera.ac.id

Fajar Paundra
Department of Mechanical Engineering
Institut Teknologi Sumatera
Email: fajar.paundra@ms.itera.ac.id

Anas Maulana
Department of Mechanical Engineering
Institut Teknologi Sumatera
Email: anas.17117063@student.itera.ac.id

Abdul Muhyi
Department of Mechanical Engineering
Institut Teknologi Sumatera
Email: abdul.muhyi@ms.itera.ac.id

Akhmad Nurdin
Manufacturing Design Engineering Technology
Politeknik Manufaktur Ceper
Email: nurdin@polmanceper.ac.id

Indriyani
Departement of Mechanical Engineering
Universitas Sang Bumi Ruwa Jurai
Email: intannaila@gmail.com

ABSTRAK

Komposit adalah kombinasi dari dua atau lebih bahan yang berbeda dengan sifat mekanik yang berbeda. Tujuan dari penelitian ini adalah untuk mengetahui pengaruh orientasi sudut tenunan komposit bertulang serat Boehmeria Nivea terhadap sifat fisis dan mekanik. Serat Boehmeria Nivea direndam dalam larutan basa dan dibuat tali dengan diameter 2-3 mm kemudian dianyam dengan orientasi sudut 0º/15º, 0º/30º, 0º/45º dan 0º/90º. Proses pembuatan komposit menggunakan metode press moulding. Pengujian pada penelitian ini terdiri dari uji tarik dengan standar ASTM D3039, uji lentur dengan standar ISO 178 dan uji densitas dengan standar ASTM C271. Hasil uji tarik menunjukkan bahwa kekuatan tarik tertinggi terjadi pada orientasi sudut anyaman 0°/15°, yaitu sebesar 13,77 MPa. Sedangkan hasil uji lentur tertinggi terjadi pada orientasi sudut webbing 0°/15°, yaitu sebesar 60,52 MPa. Kekuatan tarik dan lentur meningkat dengan orientasi sudut anyaman yang lebih kecil.

Kata Kunci: komposit, sudut orientasi, uji tarik, uji lentur.

ABSTRACT

Composites are a combination of two or more different materials with different mechanical properties. The purpose of this research was to determine the effect of the angle orientation of the Boehmeria Nivea fiber-reinforced composite woven on the physical and mechanical properties. Boehmeria Nivea fiber is soaked in an alkaline solution and made into ropes with a diameter of 2-3 mm and then woven with angle orientations of 0º/15º, 0º/30º, 0º/45º and 0º/90º. The composite manufacturing process uses the press molding method. The tests in this study consisted of a tensile test with the ASTM D3039 standard, a flexural test with the ISO 178 standard and a density test with the ASTM C271 standard. Tensile test results show that the highest tensile strength occurs at 0°/15° webbing angle orientation, which is 13.77 MPa. While the highest flexural test results occur at the orientation of the 0°/15° webbing angle, which is 60.52 MPa. Tensile and flexural strength increases with smaller webbing angle orientation.

Keywords: *composites, orientation corner, tensile, flexural.*

1. INTRODUCTION

The development of the times is closely related to the increasing need for materials. With the increase in material requirements, material technology continues to be developed. Composite is a material technology that is still being developed.

Composite is a combination of two or more materials that are not homogeneous and have different mechanical properties [1][2][3]. Composites are composed of fibers that act as reinforcement and binding material in the form of a matrix [3][4]. Fiber composites are developed and used as an alternative to other materials in the form of wood, metal and other natural materials [5]. This is because composites made of fiber are corrosion resistant, lighter, the manufacturing process is easy and relatively inexpensive [6]. The strength of the composite is influenced by its constituent fibers because the fiber is the main part of the load-bearing [7]. Based on the reinforcing material, the fiber is divided into synthetic fibers and natural fibers [8].

Synthetic fiber composites began to be abandoned and shifted towards natural fiber composites. This is because synthetic fiber composite waste is difficult to decompose and takes a long time [2][4]. While natural fiber composites have several advantages over synthetic fibers, namely high specific strength, environmentally friendly, cheaper and not harmful to health [9][10]. Then it is supported by the potential of Indonesia's plant wealth which is very abundant in natural fibers such as coconut, banana, pandanus and Boehmeria Nivea plants [11].

Boehmeria Nivea plants are clump-shaped and have fibers in the bark [7]. Boehmeria Nivea fiber has advantages in the form of good tensile strength and absorption values as well as resistance to moisture, bacteria and heat. So that Boehmeria Nivea fiber is widely used as a composite material [7]. Several ways have been done to increase the strength of the Boehmeria Nivea fiber composite, including those carried out by Purboputro & hariyanto, 2017[7]. This research investigated the effect of alkali treatment on the tensile strength and impact of Boehmeria Nivea fiber composites. Meanwhile Zainuri, dkk 2015[13], conducted a study on the effect of webbing type and volume fraction of Boehmeria Nivea fiber on impact and flexural strength.

Many research has been carried out on Boehmeria Nivea composites, but research on the orientation of the webbing angles on Boehmeria Nivea fiber composites has never been done. So it is necessary to do further research on the effect of the angle orientation of the Boehmeria Nivea composite webbing on the tensile and flexural strength.

2. METHODOLOGY

The materials used in this research were 40% Boehmeria Nivea as fiber and resin (Unsaturated Polyester Resin Yukalac C-108B) as a matrix. Boehmeria Nivea fiber is soaked in

5% alkaline solution for 2 hours, this aims to clean the fiber from dirt, so that the resin can bind perfectly to the fiber [13]. After drying, the fibers are made into ropes with a diameter of 2 mm and then woven with angle orientations of 0º/15º, 0º/30º, 0º/45º and 0º/90º. Figure 1 shows an image of webbing angle orientations.

The process of making composites is carried out at the Mechanical Engineering Fabrication Laboratory of the Sumatra Institute of Technology with the press molding method. The composite mold is 20 x 25 x 5 mm, the composite is pressed for 24 hours with a pressure of 5 bar. Density, tensile and flexural tests were conducted to determine the composite characteristics. The density test refers to ASTM C271, the tensile test refers to ASTM D3039 and the flexural test refers to the ISO 178 standard. This test was carried out at the Mechanical Engineering Materials Laboratory, Sumatra Institute of Technology.

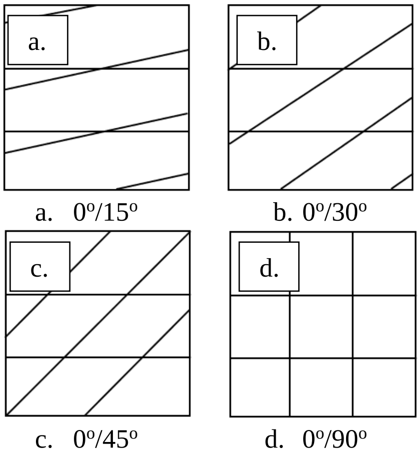
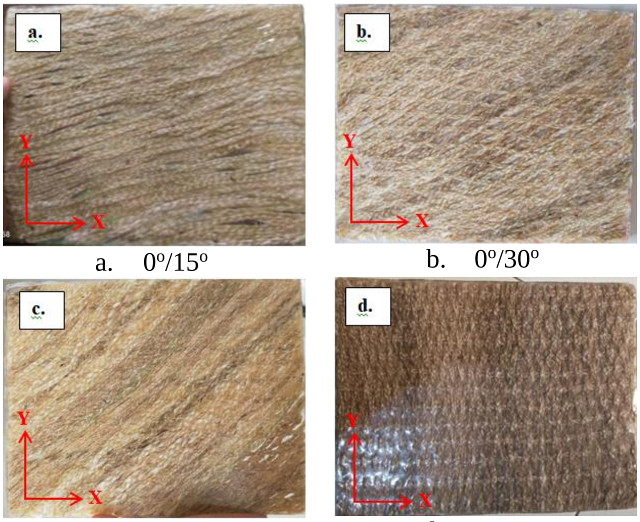


Figure 1. Webbing angle orientations

3. RESULT AND DISCUS

3.1 Composites

After the pressing process of the Boehmeria Nivea fiber woven composite with webbing angle orientation 0°/15°, 0°/30°, 0°/45°, 0°/90° obtained four variations of composite boards as shown in Figure 2. The orientation of the webbing angle means the amount of the webbing angle used with respect to the X-axis of the composite. Figures 2a and 2b show that the composite is stretched due to the uneven distribution of fibers[14]. Then in Figure 2.d shows the composite has a resin shortage. Overall, the composite board still has a lot of voids in it. Void itself occurs because in the pressing process there is air trapped in the composite[15]. In addition, this is due to the imperfect spread of the resin in coating the fiber [16]. This void can affect the quality of the composite both in terms of strength and density [17][18].



a. 0°/15° b. 0°/30°

c. 0°/45° d. 0°/90°

Figure 2. Composite boards

3.2 Density test

After visual observation of the *Boehmeria Nivea* composite, a density test was carried out. The results of the density test are presented in graphical form in Figure 3. Figure 3 shows a graph of the results of the composite density test. The graph changes the density value at each orientation of the webbing angle. The difference in density values for each orientation of the webbing angle is not too large. One of the factors causing this difference in density values is the voids that occur in the composite. Void is an empty cavity containing air bubbles in the composite[16]. This void occurs because during the resin manufacturing process it is difficult to spread and reach all parts of the fiber[15]. The number of voids greatly affects the quality of the composite, the more voids contained in the composite can cause a decrease in composite density and mechanical strength[17][18].

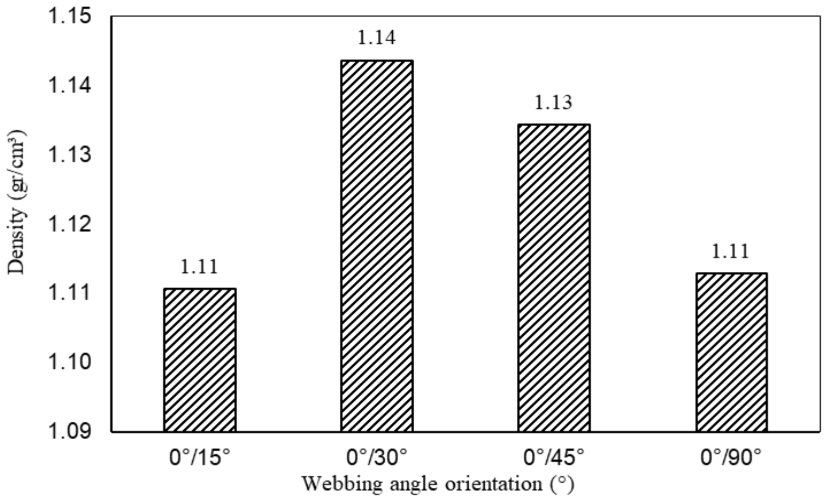


Figure 3. Graph of density test results

3.3 Tensile test

The results of testing the tensile strength of the Boehmeria Nivea fiber woven composite at various webbing angles are presented in the graph in Figure 4. Figure 4 shows a graph of the results of the tensile strength of the Boehmeria Nivea woven fiber composite. The decrease in tensile strength value from 0°/15° orientation to 0°/30° orientation is 0,65 MPa. Then from 0°/30° orientation to 0°/45° orientation is 3,09 MPa. Then from 0°/45° orientation to 0°/90° orientation is 2,04 MPa. The decrease in tensile strength is in line with the magnitude of the orientation of the webbing angle on the composite. This happens because the greater the orientation of the webbing angle used, the shorter the fibers contained in the composite [4][19][20]. On the other hand, long fibers have a crystal structure that is arranged along the fiber axis and is more perfect [21][22].

The angular orientation of the composite woven greatly influences the fracture of the tensile test results. Figure 5 shows a picture of the tensile test fractures that occur in the *Boehmeria Nivea* fiber-reinforced woven composite. The fracture that occurs in the composite is a debonding fault. Where the matrix breaks first because it is unable to withstand the shear force so that the interface bond between the fiber and the matrix is released[23][24]. The matrix was broken first due to the inappropriate volume fraction ratio. Too much fiber volume fraction causes the matrix volume to be small. With a small matrix, the matrix cannot bind and maintain the fiber position properly [25].

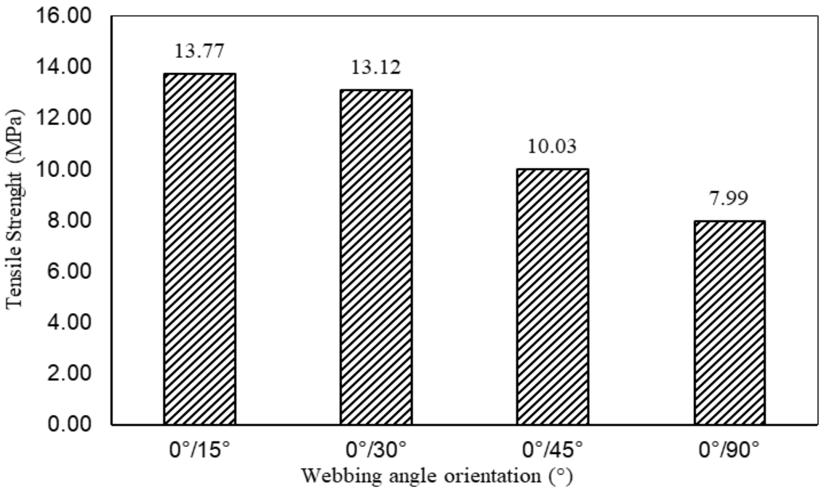


Figure 4. Graph of tensile test results

Figure 5 shows the direction of the fracture following the angular orientation of the woven fibers. The fracture that occurs in the composite still looks bound but has lost its ability to withstand the load in the direction of the tensile force. But at 0°/15° webbing orientation the fractures in the composite are no longer bonded. This is because in the 0°/15° woven orientation composite there is no fiber in the direction of loading. So that the tensile strength of the 0°/15° webbing orientation is not maximal and causes the load to not be distributed vertically and evenly on the fiber [26][27]. This causes the decrease in tensile strength from 0°/15° orientation to 0°/30° orientation is very small.

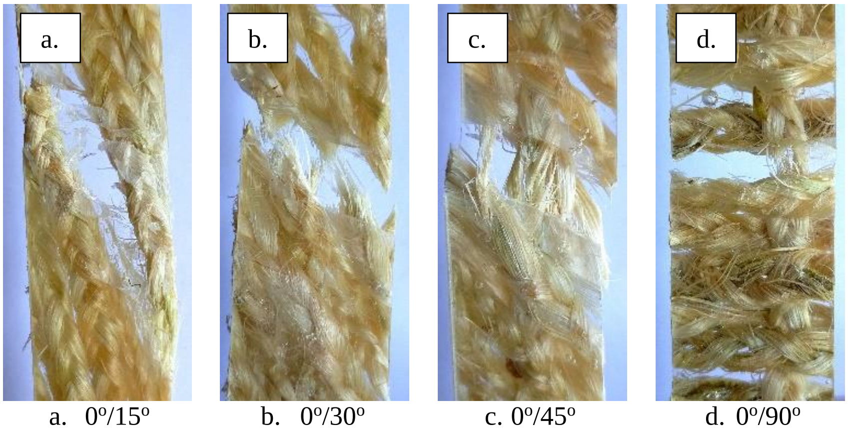


Figure 5. Tensile test fracture

In addition to volume fraction, composite fracture can also be caused by several factors. One of the factors is the initial damage before testing as shown in Figure 6. Figure 6 shows the composite fracture results. The red circle shows the voids in the tensile test fracture area. Void can reduce the tensile strength of the composite because it cannot distribute the load received by the composite to the fiber evenly[25][28]. Figures 6 b and c have voids on the fault due to the large size of the voids. In addition to being due to voids, the decrease in composite strength is also due to the presence of fibers being pulled out of the matrix or called pull outs [2][27]. Pull out occurs because the matrix and fiber do not bind perfectly. Dense woven fibers can cause the matrix to not flow throughout the cavity. This causes an empty gap that is not filled with resin (voids) [15][29]. So that when a load is applied to the composite, the stress will move to the void area until a fracture occurs [18].

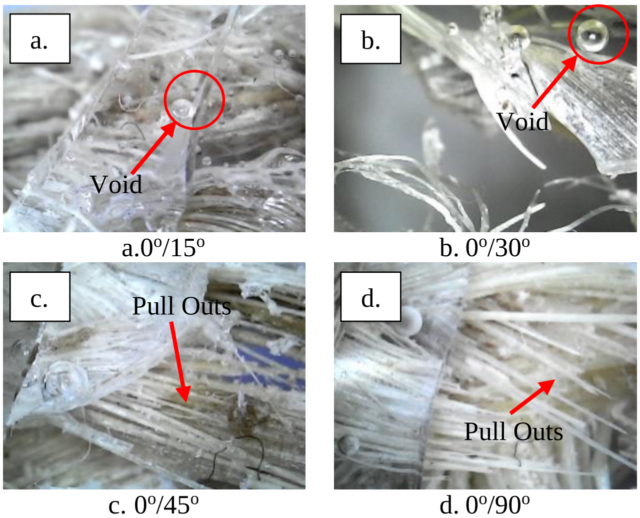


Figure 6. Tensile test fracture

Jurnal Media Mesin, Vol. 24 No. 1
Printed ISSN: 1411-4348
Online ISSN: 2541-4577

3.4 Flexural test

The results of testing the flexural strength of the Boehmeria Nivea fiber woven composite on the variation of the webbing angle are presented in the graph in Figure 7. Figure 7 shows the change in flexural strength affected by the angular orientation of the webbing. The smaller the orientation of the webbing angle, the greater the value of the flexural strength [30][24]. This is because the smaller the angular orientation of the webbing, the more fibers are arranged closer to the x-axis. Where the fiber on the x-axis is the dominant fiber receiving flexural loads. Meanwhile, the greater the orientation of the webbing angle, the more fibers are arranged closer to the y-axis. While the y-axis fiber acts as a binder in the flexural test.

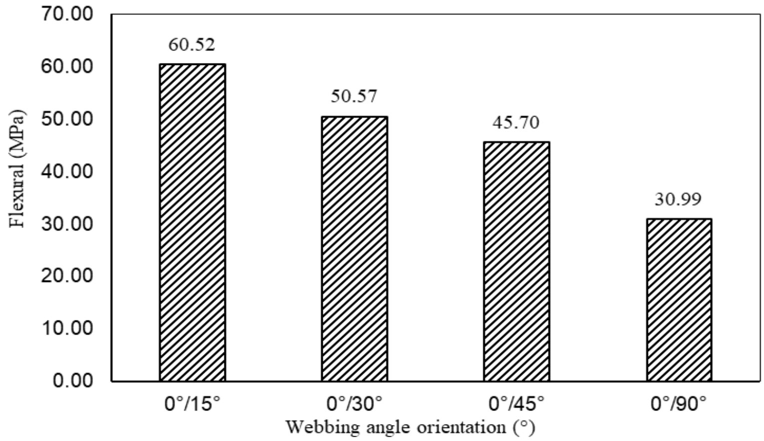
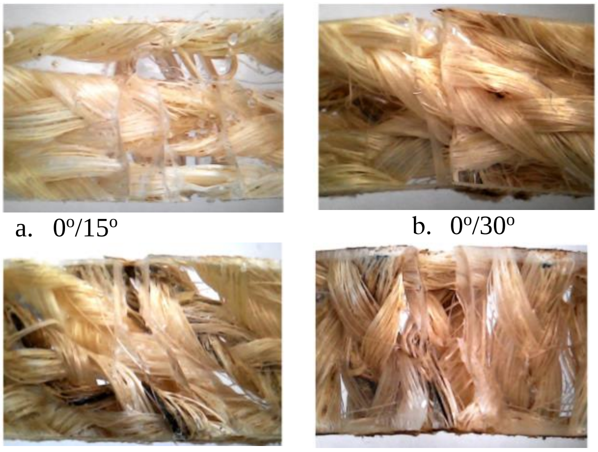


Figure 7. Flexural test graph

The fracture in the flexural test can be seen in figure 8. The flexural strength in this test has a strength value that increases with the number of fibers parallel to the x-axis, which is the dominant axis to withstand flexural loads. In the 0°/15° variation there are voids and pull outs on the fault. Then at variations of 0°/30° and 0°/90° there is a pull out on the fault. At the 0°/90° variation, the specimen lacked fiber, resulting in a fracture in the fiber-deficient area. These factors cause the results of the flexural strength that are less than the maximum in the test [31][32][33].



a. 0°/15°
b. 0°/30°
c. 0°/45°
d. 0°/90°

Figure 8. Flexural test fracture

4. CONCLUSIONS

Based on the calculations and analysis obtained from the results of this final project, it can be concluded:

1. The angle orientation of the webbing affects the tensile and flexural strength. The orientation of the angle closer to the tensile direction, the greater the tensile and flexural strength. The highest tensile and flexural strengths (13,77 MPa and 60,52 MPa) were produced by Boehmeria Nivea composite with woven angle orientation 0°/15°.
2. The highest tensile and flexural strength values are angle orientation 0°/15° with a tensile strength value of 13,77 MPa and a flexural strength value of 60,52 MPa. Then the lowest tensile and flexural strength values are angle orientation 0°/90° with a tensile strength value of 7,99 MPa and a flexural strength value of 30,99 MPa.

Further research that can be planned to complement this research includes morphological observations using a Scanning Electron Microscope or SEM. Through SEM observations, the failure area during destructive testing can be enlarged and further analyzed.

REFERENCES

[1] Sarudin, Sudarsono, and G. Yuspian, "Karakteristik Kekuatan Tarik pada Komposit Hybrid , Serat Rami , Fiberglass , dan Resin Polyester," *ETHALPHY J. Ilm. Mhs. Tek. Mesin*, vol. 4, no. 4, pp. 124–128, 2019.

[2] M. Muhajir, M. A. Mizar, D. A. Sudjimat, and J. P. T. Mesin-ft, "Analisis Kekuatan Tarik Bahan Komposit Matriks Resin Berpenguat Serat Alam Dengan Berbagai Varian Tata Letak," *J. Tek. Mesin*, vol. 24, no. 2, pp. 1–8, 2016.

[3] L. Banowati, W. A. Prasetyo, and D. M. Gunara, "Analisis Perbandingan Kekuatan Tarik Orientasi Unidirectional 0(Dan 90(Pada Struktur Komposit Serat Mendong Dengan Menggunakan Epoksi Bakelite Epr 174," *Infomatek*, vol. 19, no. 2, p. 57, 2017, doi: 10.23969/infomatek.v19i2.627.

[4] A. Saidah, S. E. Susilowati, and Y. Nofendri, "Pengaruh Fraksi Volume Serat Terhadap Kekuatan Mekanik Komposit Serat Jerami Padi Epoxy Dan Serat Jerami Padi Resin Yukalac 157," *J. Konversi Energi dan Manufaktur UNJ*, pp. 96–101, 2018.

[5] F. Paundra, T. Triyono, and W. P. Raharjo, "Cu Addition Effect Analysis on Matrix Of Remelting Piston Aluminium Composite with Silica Sand Reinsforcement to The Impact Strength and Micro Structure on Aluminuim Matrix Composite Using Stir-Casting Method," *Mek. Maj. Ilm. Mek.*, vol. 16, no. 1, pp. 20–25, 2017, doi: 10.20961/mekanika.v16i1.35051.

[6] I. K. A. Widi, W. Sujana, G. A. Pohan, and P. S. Saskara, "Analisa Uji Tarik Dan Impak Komposit Epoxy Rami -Agave – Karbon dengan Campuran Epoxy-Karet Silikon (30%, 40%, 50%)," *J. Flywheel*, vol. 11, no. 1, pp. 10–14, 2020, doi: 10.36040/flywheel.v11i1.2506.

[7] P. I. Purboputro and A. Hariyanto, "Analisis Sifat Tarik Dan Impak Komposit Serat Rami Dengan Perlakuan Alkali Dalam Waktu 2,4,6 Dan 8 Jam Bermatrik Poliester," *Media Mesin Maj. Tek. Mesin*, vol. 18, no. 2, pp. 64–75, 2017, doi: 10.23917/mesin.v18i2.5238.

[8] R. T. Setyawan and S. Riyadi, "Analisis Variasi Struktur Serat Rami Komposit Matrik Epoksi Terhadap Kekuatan Uji Balistik Dan Bending," *J. Ilm. Momentum*, vol. 16, no. 2, pp. 111–115, 2020, doi: 10.36499/mim.v16i2.3763.

[9] M. Syaukani, F. Paundra, F. Qalbina, I. D. Arirohman, and P. Yunesti, "Desain dan Analisis Mesin Press Komposit Kapasitas 20 Ton," *Journal of Science, Technology, and*

Visual Culture, Vol.1, No.1, pp. 29–34, 2021.

[10] Z. D. Zulkifli Ida Bagus, “Analisa Pengaruh Perlakuan Alkalisasi Dan Hydrogen Peroksida Terhadap Kekuatan Mekanik Komposit Serat Sabut Kelapa Bermatriks Epoxy,” *J. POLIMESIN*, no. Vol 17, No 1 (2019): Polimesin, pp. 41–46, 2019.

[11] M. M. Ilham and H. Istiqlaliyah, “Pemanfaatan Serat Rami (Boehmeria Nivea) Sebagai Bahan Komposit Bermatrik Polimer,” *J. Mesin Nusant.*, vol. 2, no. 1, pp. 34–41, 2019.

[12] A. Zainuri, N. H.S., and M. Z. J., “Kekakuan Bending Eksperimen Komposit Sandwich Serat Sabut Kelapa - Matrik Polyester,” *Jurnal Mesin,* Vol.2, pp. 30–35, 2005.

[13] A. A. Mohammed, D. Bachtiar, M. R. M. Rejab, and J. P. Siregar, “Effect of microwave treatment on tensile properties of sugar palm fibre reinforced thermoplastic polyurethane composites,” *Def. Technol.*, vol. 14, no. 4, pp. 287–290, 2018.

[14] I. Munandar, S. Savetlana, and S. Sugiyanto, “Kekuatan Tarik Serat Ijuk (Arenga Pinnata Merr),” *J. Ilm. Tek. Mesin FEMA*, vol. 1, no. 3, p. 97942, 2013.

[15] G. Gundara, “Analisis Sifat Fisis dan Mekanis Komposit Serat Gelas Berlapis,” *Semin. Nas. Teknoka*, vol. 2, no. 2502, pp. M17–M21, 2017.

[16] N. Nopriantina and A. -, “Pengaruh Ketebalan Serat Pelapah Pisang Kepok (Musa Paradisiaca) Terhadap Sifat Mekanik Material Komposit Poliester-Serat Alam,” *J. Fis. Unand*, vol. 2, no. 3, pp. 195–203, 2013, doi: 10.25077/jfu.2.3.

[17] R. R. Rizkiansyah and I. Purnomo, “Sifat Mekanik Komposit Polipropilena Berpenguat Serat Sansevieria Unidirectional,” *Mesin*, vol. 25, no. 2, pp. 73–82, 2016.

[18] S. H. Firman, Muris, and Subaer, “Studi Sifat Mekanik dan Morfologi Komposit Serat Daun Nanas- Epoxy Ditinjau dari Draksi Fassa dengan Orientasi Serat Acak,” *J. Sains dan Pendidik. Fis.*, vol. 11, no. 2, pp. 185–191, 2015.

[19] C. I. P. K. Kencanawati, N. Suardana, I. K. G. Sugita, and I. W. B. Suyasa, “Pengaruh Panjang Serat Terhadap Kekuatan Tarik dan Kekuatan Impact Greencomposite Serat Kulit Buah Pinang dengan Matriks Getah Pinus,” *J. Energi Dan Manufaktur*, vol. 12, no. 1, p. 33, 2019.

[20] F. Paundra *et.,al.*, Effect of Alkali Treatment on Tensile Strength of Teki Grass Fiber Composite Materials.” *Journal of Applied Mechanical Technology, Vol.1, No.1, 2022* .

[21] P. I. Purboputro, “Pengaruh Panjang Serat Terhadap Kekuatan Impak Komposit Enceng Gondok Dengan Matriks Poliester,” *Media Mesin Maj. Tek. Mesin*, vol. 7, no. 2, pp. 70–76, 2017.

[22] F. Paundra *et al.*, “Analisis Kekuatan Tarik Komposit Hybrid,” *Jurnal Mechanical Engineering,* vol. 11, no. 1, pp. 9–13, 2022.

[23] A. Chandra and A. Asroni, “Pengaruh Komposisi Resin Poliyester Terhadap Kekuatan Bending Komposit Yang Diperkuat Serat Bambu Apus,” *Turbo J. Progr. Stud. Tek. Mesin*, vol. 4, no. 2, pp. 41–46, 2017.

[24] F. Paundra *et al.*, “Analisis Kekuatan Tarik Komposit Hybrid,” *Jurnal Mechanical Engineering,* Vol. 11, No. 1, pp. 9–13, 2022.

[25] R. Fajri, T. Tarkono, and S. Sugiyanto, “Studi Sifat Mekanik Komposit Serat Sansevieria Cylindrica Dengan Variasi Fraksi Volume Bermatrik Polyester,” *J. Ilm. Tek. Mesin FEMA*, vol. 1, no. 2, p. 97963, 2013.

[26] N. P. Lestari, “Analisis Pengaruh Oientasi Serat dan Komposisi terhadap Kuat Tarik dan Modulus Elastisitas Komposit Serat Sabut Kelapa”, *Jurnal MIPA*, Vol. 1.1, pp. 1–7.

[27] A. Nurdin, S. Hastuti, H. P. D., and R. H., “Pengaruh Alkali dan Fraksi Volume terhadap Sifat Mekanik Komposit Serat Akar Wangi – Epoxy,” *Rotasi*, vol. 21, no. 1, p. 30, 2019.

[28] F. Paundra, Z. Z. Muttaqin, F. P. Nurullah, E. Pujiyulianto, F. Budi, and R. Artikel, "Pengaruh Variasi Fraksi Volum Terhadap Kekuatan Tarik Komposit Hybrid Berpenguat Serat Pelepah Pisang Dan Serat," *Journal of Science, Technology, and Visual Culture,* Vol.2, No.2, 6–8, 2022.

[29] F. Paundra, A. Naufal, A. Muhyi, F. P. Nurullah, and P. Elmiawan, "Effect of Webbing Angle on Tensile and Bending Strengths in Human Hair Fiber Reinforced Composites," *Journal of Science, Technology, and Visual Culture*, vol. 24, no. 1, pp. 30–35, 2022.

[30] A. S. N, W. Sumbodo, and R. D. Widodo, "Pengaruh Anyaman 2D Triaxial Braided Fabric Filler Kain Goni Terhadap Kekuatan Bending Dan Struktur Makro Komposit Bermatrik Polyester," *J. Kompetensi Tek.*, vol. 10, no. 2, pp. 46–53, 2018.

[31] Sarudin, Sudarsono, and Y. Gunawan, "Karakteristik Kekuatan Tarik Pada Komposit Hybrid, Serat Rami, Fiberglass, Dan Resin Polyester," *ENTHALPY J. Ilm. Mhs. Tek. Mesin J.*, vol. 4, no. 4, pp. 124–128, 2019.

[32] I. G. P. A. Suryawan, N. Suardana, I. K. Suarsana, I. P. Lokantara, and I. K. J. Lagawa, "Kekuatan Tarik dan Lentur pada Material Komposit Berpenguat Serat Jelatang," *J. Energi Dan Manufaktur*, vol. 12, no. 1, p. 7, 2019.

[33] A. Kadir and K. Hijau Bumi Tridarma Andounohu Kendari, "DINAMIKA Jurnal Ilmiah Teknik Mesin Pengaruh Pola Anyaman Terhadap Kekuatan Tarik Dan Bending Komposit Berpenguat Serat Bambu," vol. 6, no. 1, pp. 9–18, 2014.