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An Experimental Investigation of Tensile Strength and Impact Energy of Polymeric Foams-OPEFB Fiber Sandwich Panels Composite

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ABSTRACT

This paper discusses an experimental investigation of tensile strength and impact properties of polymeric foams-OPEFB fiber sandwich panels composite with various directions of palm empty fruit bunches fiber, vacuum pressure, and foam thickness. In this study, the manufacture of specimens with different fiber directions will then be tested and analyzed for each direction of fiber. The results of the analysis of composite specimens in the study were evaluated and compared with each other. The purpose of this study was to obtain impact energy and tensile strength of composite plates. In the manufacture of sandwich panel specimens carried out by varying the pump pressure, foam thickness, and the direction of the preparation of the fiber and carried out by the vacuum method. From the test results, it was found that the highest tensile strength was composite specimens with vertical fiber direction is specimens with three vertical panels of fiber direction, vacuum pressure 6 cm Hg, and foam thickness is 1.5 mm with tensile strength is 22.5 N/mm^2, while the highest impact energy is the specimen with vertical fiber direction is the specimen with the fiber direction of the three vertical panels, the vacuum pressure is 6 cm Hg, and foam thickness of 1.5 mm with an impact price of 0.16 J/mm^2. From this study it can be concluded that the fiber direction is 53% higher than the direction of the combined fibers vertically, horizontally, and vertically in absorbing impact loads, also 83% higher than the vertical, 45^0, and horizontal combined fibers in absorbing impact loads It also has a tensile strength of 10% higher than the vertical, horizontal and vertical combined fiber direction, also has a tensile strength of 15% higher than the vertical, 45^0 and horizontal combined fiber direction.

KEY WORDS: *polymeric foams, OPEFB fiber, sandwich panels composite, tensile strength, impact energy.*

1.0 INTRODUCTION

Riau is a province with the largest oil palm plantation in Indonesia with an area of oil palm plantations of around 2.3 million ha [1]. In addition to producing oil palm fruit as the main product of oil palm plantations, it also produces abundant empty bunches and palm shells. It is estimated that oil palm plantations in Riau produce 1099.3 tons of solid waste (fiber and shells) per day [2]. The use of waste in oil palm is generally in the form of compost, particle board, charcoal, activated carbon, and also boiler fuel at the palm oil mill [1].

Oil palm empty fruit bunches (OPEFB) have the potential to be used as natural reinforcement in the composite matrix. Composite OPEFB fibers consists of oil palm empty fruit bunches and matrix. The composition of the sandwich hollow material (foam) can increase the absorption of impact energy of the structure. Hollow material structures and designs have the potential as impact load dampers. Vaziri, A. et al [3] have conducted research on layered board structures with hollow material. Layered board design shows a significant effect on absorption energy impact. Qiao, P. et al [4] have reviewed impact energy absorbing materials. The results of [4] show that the design of hollow material structures is very influential to absorb impact energy. Badri, et al [5] have conducted a study of the polymeric foam response to impact imposition. The results obtained by [6] show that polymeric foam is effective in absorbing impact energy. Badri, M. et al [5] stated that the design of polymeric foam material products has structural stability if

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subjected to impact loads. The average tensile strength of multi-stage polymeric foam sandwich panels with OPEFB fibers was soaked with 5% NaOH solution for 2 hours higher than those boiled using water and NaOH [7]. Ramaksihnan, K.R. et al [6] have compared the differences in foam material density in layered structures, the results show that foam materials with lower density can absorb energy better.

Based on the description above, it is necessary to study the tensile and impact characteristics of polymeric foam materials with OPEFB fibers reinforced composite sandwich panels. In this study, variations in OPEFB fibers, vacuum pump pressure, and foam thickness will be seen in their effect on the tensile strength and impact energy of OPEFB fibers reinforced composite.

2.0 EXPERIMENTAL METHOD

2.1 Specimen preparation

Polyester resin is used as a matrix in the manufacture of composites. The polyester resin used is Eternal 2250 resin with MEKPO (Methyl Ethyl Ketone Peroxide) catalyst as its hardener. Polymeric Foam is used as a layer between 3 parts of the composite plate before being combined into 1 specimen OPEFB fiber used in the manufacture of this composite is OPEFB fiber with a fiber length of 1-5 cm and a fiber diameter of 0.1 mm - 0.5 mm.

The first of fiber treatment is OPEFB drying process, OPEFB fiber is then separated from the oil palm bunches that have been dried to dry conditions. OPEFB fiber which has been separated from the stem is then boiled in water at a temperature of 50º C. The type of water used during boiling is distilled water so it does not affect the pH of the OPEFB fibers. Boiling OPEFB fiber is carried out for 30 minutes using a heater with a thermostat so that a temperature of 50º C can be achieved.

Figure 1 shows the heating of fibers in the furnace. OPEFB fiber is then dried by drying in the sun until the percentage of water in the fiber is less than 13%. After the fiber is dried and the dry fiber is obtained, then to find out the moisture content of OPEFB fiber, the fiber is tested for water content in Laboratory of Chemical Reaction Engineering Universitas Riau, OPEFB fibers samples were then measured as 2 grams. After the measurement process of OPEFB fiber test sample, then the fiber is heated into the furnace at a temperature of 105º C.

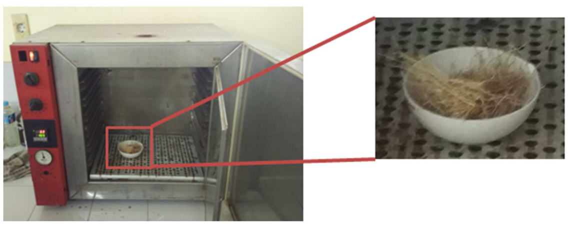

Figure 1: Heating of OPEFB fibers in the furnace

Figure 2 shows the direction of the OPEFB fiber arrangement. OPEFB fibers are then arranged on the mold according to the direction of the predetermined arrangement: vertical (a), horizontal (b), and 45º(c).

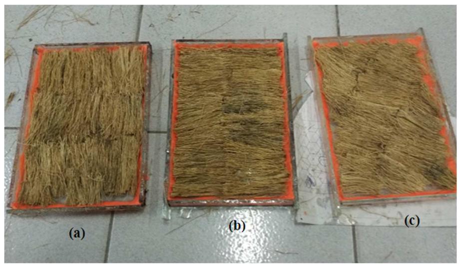

Figure 2: Direction of the OPEFB fiber arrangement

Figure 3 shows composite mold preparation. After OPEFB fibers is arranged, then the resin is poured into the mold so that it fills the fibers in the mold, the mold is then put into plastic and isolated. The mold conditions under vacuum.

Figure 3: Polymeric foams-OPEFB fiber sandwich panels composite mold preparation

Figure 4 shows the composite vacuum process. The hose is then mounted on the corner of the plastic which will connect the mold and vacuum. The process continued with specimen manufacturing using vacuum techniques. The first procedure is to turn on the vacuum pump, then adjust the pressure by closing the inlet. The next procedure adjusts the control valve opening to adjust the pressure, the pointer on the manometer moves towards the pressure scale number used. The conditioned pressure for each different specimen is 2, 4 and 6 cm Hg.

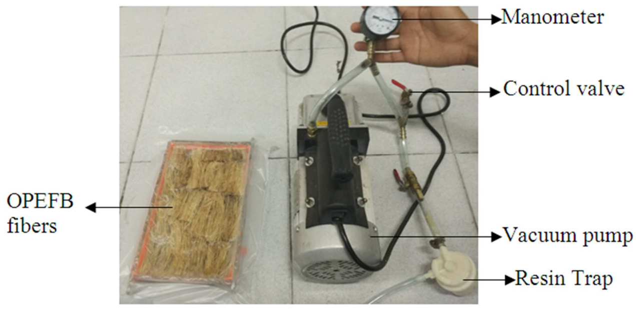

Figure 4: Vacuum assisted resin infusion

Test specimens are in accordance with the required standards, ASTM D 638-02 tensile test and ASTM D 256-02 impact test.

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-Science and Engineering-
30th September 2018. Vol.59 No.1

2.2 Experimental setup

Tensile testing was carried out to determine the tensile strength of OPEFB fiber composite material. Tests are carried out by slowly loading the soil until the specimen breaks. Testing was carried out with Universal Testing Machine in Laboratory of Material Testing, Department of Mechanical Engineering, Universitas Riau. Figure 5 shows the test specimen on the tensile testing machine

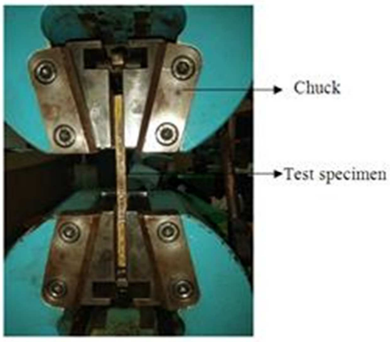

Figure 5: Setup of tensile test specimen (ASTM D 638-02)

The impact test is carried out to determine the impact energy that can be absorbed by the OPEFB composite plate until it breaks. The test is done by giving the specimen a high strain rate loading conditions. Tests were carried out with an impact testing machine in the Laboratory of Material Testing, Department of Mechanical Engineering, Universitas Riau. The test data taken is the impact energy of each specimen. The tread test was carried out by the Charpy method with room temperature, after the specimen was placed on the impact test apparatus, the specified α angle was 60^0. Then the impact test device is operated so that the pendulum hits the test specimen, and obtains the angle β. Figure 6 shows the Charpy impact testing setup.

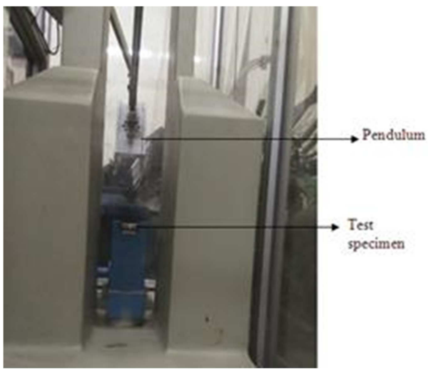

Figure 6: Setup of impact test specimen (ASTM D 638-02)

3.0 RESULTS AND DISCUSSION

Composites that have been made in this research are OPEFB fiber composite plates with the resulting size of 250 mm x 150 mm with a thickness of 3 mm. This composite plate was cut into test specimen sandwich panels with 3 layers of composite plates and 2 polymeric foam layers in accordance with ASTM D638-02 standard for tensile testing and ASTM D256-02 for impact testing Figure 7 shows polymeric composite-OPEFB fiber sandwich composite panels.

Figure 7: Polymeric composite-OPEFB fiber sandwich composite panels

Figure 8 shows the tensile strength of OPEFB fiber composites with vertical OPEFB fibers direction. From Figure 8 can be seen the tensile strength of OPEFB fiber composites with vertical fiber direction. The highest tensile strength was found in specimens with a vacuum pressure of 6 cm Hg which was 22.5 N/mm^2

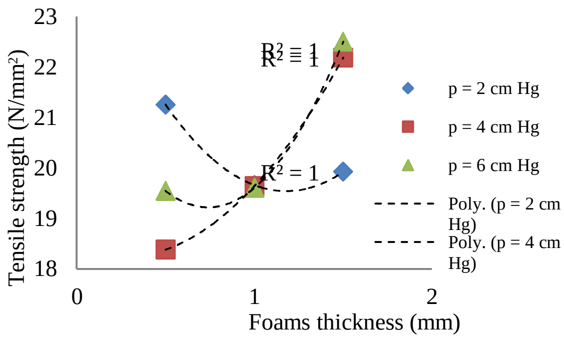

Figure 8: Effect of vertical direction of OPEFB fibers to tensile strength of polymeric foams sandwich panels composite

At a vacuum pressure of 4 cmHg and 6cmHg appear to have increased in tensile strength along with the increase in thickness of the foams. while at a pressure of 2 cmHg had decreased even though the thickness of foams was increased. This is because the foam thickness does not affect the tensile strength of the composite. The tensile strength of the vertical OPEFB fiber direction is not too much different for each pressure variation and foam thickness.

Figure 9 shows the tensile strength of OPEFB fiber composites with horizontal fiber direction. The highest tensile strength is found in composite polymeric Foams - OPEFB fiber sandwich panels with a vacuum pressure of 2 cm Hg which is equal to 20.4 N/mm^2. At 4 cmHg and 6cmHg the pressure appears to have increased in tensile strength along with the addition of foam thickness. While at a pressure of 2 cmHg decreased even

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though given the addition of foam thickness. Tensile strength of the horizontal fiber direction is not too much different for each variation of pressure and foam thickness.

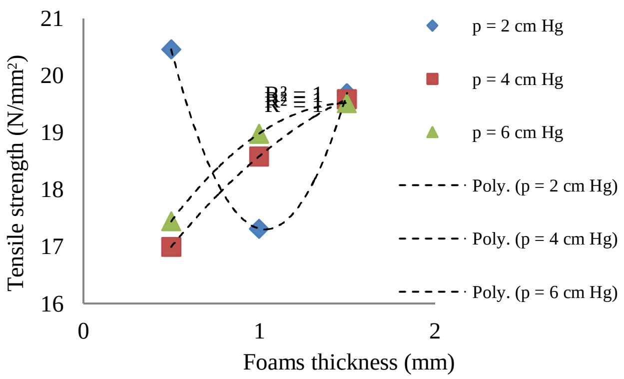

Figure 9: Effect of horizontal direction of OPEFB fibers to tensile strength of polymeric foams sandwich panels composite

Figure 10 shows the tensile strength of OPEFB fiber composites with 45° fiber direction. The highest tensile strength is found in specimens with a vacuum pressure of 6 cmHg which is equal to 19.5 MPa

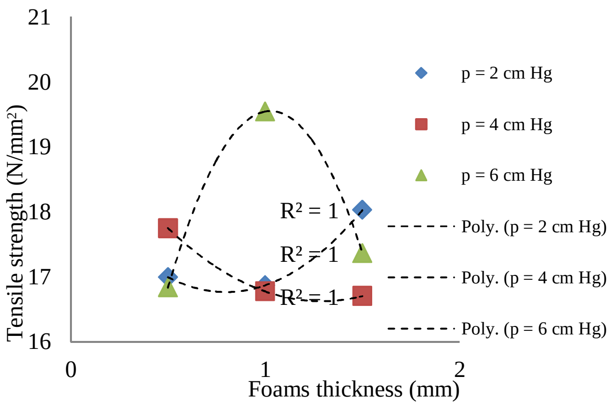

Figure 10: Effect of 45° direction of OPEFB fibers to tensile strength of polymeric foams sandwich panels composite

Tensile strength of polymeric foams - OPEFB fiber sandwich panels was composited with a vacuum pressure of 4 cmHg decrease with increasing foam thickness. For a vacuum pressure of 2cmHg the increase in tensile strength along with the addition of foam thickness. While at a pressure of 6 cmHg decreases and increases the maximum tensile strength randomly.

Figure 11 shows the highest tensile strengths are polymeric foam - OPEFB fiber sandwich composite panels with vertical fiber direction. The vertical fiber direction is 3 layers of panels with each panel printed in the same fiber direction

The highest tensile strength in polymeric foam - OPEFB fiber sandwich composite panels with vertical fiber direction.

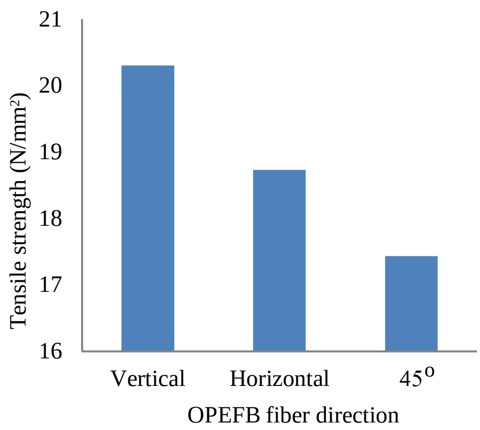

Figure 11: Average Tensile Strength Based on OPEFB Fiber Direction

The tensile strength of the vertical fiber direction is high because the direction of the OPEFB fiber composite fiber is in the direction of the given load so that the load can be retained by the interface bond between the fiber and matrix. OPEFB fiber which extends in the direction of loading causes the matrix interface bond to become stronger because the load received is distributed to the fiber received by the matrix. OPEFB fiber which is longer means that the load distributed will be longer too. This investigation shows that composites with the same direction with loading direction have a higher tensile strength than the other directions.

Figure 12 shows the impact energy absorbed from polymeric foam - OPEFB fiber sandwich composite panels with vertical fiber direction. The highest impact energy that can be absorbed is found in the composite with a vacuum pressure of 6 cmHg which is 202.9 J.

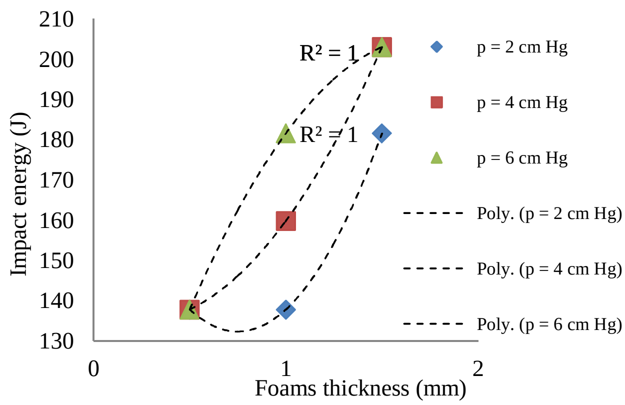

Figure 12: Effect of vertical direction of OPEFB fibers to impact energy of polymeric foams sandwich panels composite

For composites manufactured with a vacuum pressure of 4 cmHg and 6cmH, the increased impact energy was absorbed as

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the foam thickness increased. This analysis shows that foam thickness affects the impact load absorbed by the composite.

Figure 13 shows polymeric foam impact energy - OPEFB fiber sandwich composite panels with horizontal fiber direction. the highest impact energy that can be absorbed is in the specimen with a vacuum pressure of 6 cmHg which is 137.8 J. For 4 cmHg and 6cmH pressure conditions it is also seen to have increased impact energy along with the increase in foam thickness.

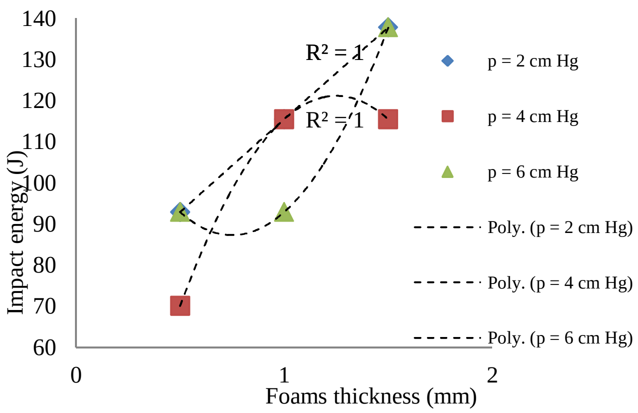

Figure 13: Effect of horizontal direction of OPEFB fibers to impact energy of polymeric foams sandwich panels composite

Figure 14 shows polymeric foam impact energy - OPEFB fiber sandwich composite panels with 45° fiber direction. The highest impact energy that can be absorbed is in the specimen with a vacuum pressure of 6 cmHg which is 115.5 J.

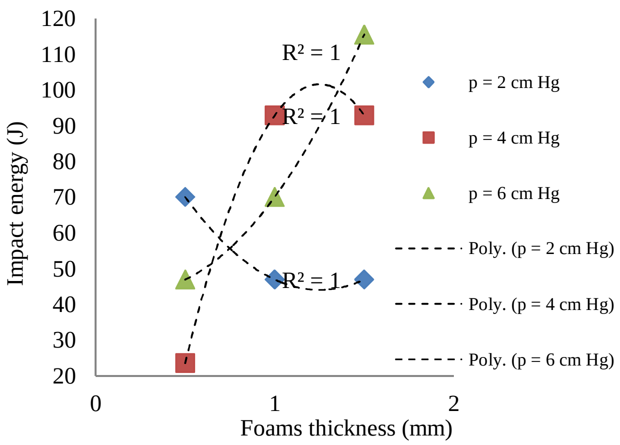

Figure 14: Effect of 45° direction of OPEFB fibers to impact energy of polymeric foams sandwich panels composite

Figure 15 shows the average impact energy of OPEFB fibers for impact energy of polymeric foam - OPEFB fiber sandwich composite panels. The highest impact energy that can be absorbed is OPEFB fiber composite with vertical fiber direction, at 164.4. OPEFB fiber composite with horizontal fiber direction is 107.9 J. While composite with 45 fiber direction is obtained as 67.3 J. The distribution of impact load in the direction of the composite fiber causes the composite with the direction of the fiber (vertical) to have a higher impact energy impact compared to the direction of the other fibers.

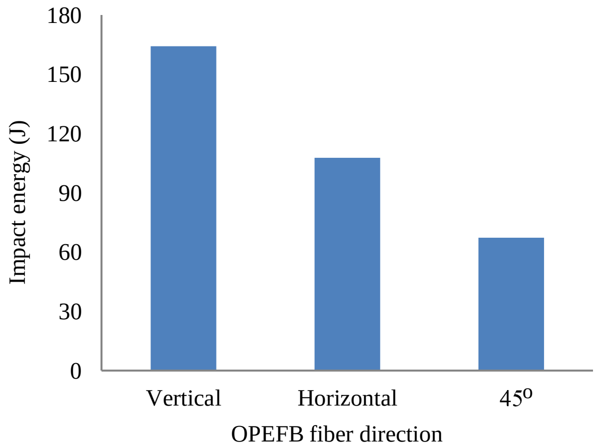

Figure 15: Average Impact Energy Based on OPEFB Fiber Direction

5.0 CONCLUSION

This work has reported the experimental study of tensile strength and impact energy of polymeric foams-OPEFB fiber sandwich panels composite. It was found that the tensile strength and impact energy absorbed by the composite were influenced by the direction of the OPEFB fiber, the thickness of the foam layer, and the vacuum pressure given at the time of manufacturing this composite. The orientation of the OPEFB fiber in the direction of loading can respond to a higher tensile strength compared to the orientation of the other fibers. The thickness of the foam layer affects the impact energy that can be absorbed. The more foam thickness increases, the higher the impact energy absorbed. For the vacuum pressure given in this study is 6 cm Hg.

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REFERENCE

1. Anonim. 2015. *Statistik Pekebunan Indonesia Kelapa Sawit*. Edisi 1. Direktorat Jendral Perkebunan Republik Indonesia. Jakarta.

Journal of Ocean, Mechanical and Aerospace
-Science and Engineering-
30th September 2018. Vol.59 No.1

2. Moenif, E. M. 2012. *Potensi, Pengembangan dan Target Implementasi Energi Terbarukan di Propinsi Riau.*
3. Vaziri A, Xue Z, dan Hutchinson J W. 2006. Metal Sandwich Plates with Polymer Foam Filled Cores. *Journal of Mechanics of Material and Structuries* 1(1): 95-125.
4. Qiao P and Bibienda W K. 2008. “Impact mechanics of composite materials for aerospace application.” J. Aerosp. Eng., 21(3), 117–118.
5. Badri M, Syam B, Rizal S, and Buana K S. 2010. Respons Polymeric Foam yang diperkuat Serat Tandan Kosong Kelapa Sawit (TKKS) Akibat Beban Tekan Stastik dan Impak(Simulasi Numerik). *Jurnal Dinamis* 1(7): 45-60.
6. Ramakrishnan K R, Shankar K, Viot P, and Guerard S. 2012. A Comparative Study of The Impact Properties of Sandwich Material with Different Cores. *Jurnal of Web of Conferences* 26(1031): 1-6.
7. Badri M, Arief D S, Johanes E S, and Rahmat R Z. 2017. Mechanical Behavior of OPEFB Fiber Reinforced Polymer Composites - Polymeric Foam Sandwich Panels under Static Loading Conditions. *International Journal of Environmental Research & Clean Energy* 10 (1): 1-6.