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Effect of OPEFB treatment on the mechanical behavior of polymeric foams-OPEFB fiber sandwich panels composite

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ABSTRACT

This work investigated the effects of oil palm empty fruit bunch (OPEFB) fiber treatment on mechanical behavior of polymeric composite-OPEFB fiber sandwich composite panels. The treatment method used is boiling and chopped OPEFB fiber. The treatment with boiling and soaking fiber varied: boiling in water temperature 50^{o}C for 30 minutes, soaking in room temperature with NaOH for 2 hours, boiling with NaOH solution at a temperature of 50^{o}C for 30 minutes. The time of chopping the fiber is varied from 1 to 3 minutes at two speed of cutting tools which are 1280 and 2560 rpm. OPEFB fiber orientation in this study is a random discontinuous direction. Laminates on polymeric foam composites consist of 3 sandwich layers. Polymeric composite-OPEFB fiber sandwich composite manufacturing with vacuum assisted resin infusion (VARI) method. The obtained summaries are as follows: (1) The tensile strength and impact value of polymeric composite-OPEFB fiber sandwich composite panels are influenced by the fiber treatment method. In this work, tensile strength and impact of composite with OPEFB fiber boiled in water 50^{o}C higher than other fiber treatments. (2) The time and speed of fiber chopping influence the tensile strength and impact of polymeric composite-OPEFB fiber sandwich composite panels. tensile strength and impact decreases with increasing time and speed of cutting tools on OPEFB fiber chopping.

KEY WORDS: *OPEFB treatment, polymeric foams, OPEFB fiber, tensile strength, impact value.*

1.0 INTRODUCTION

The interior industry is currently growing, one of the interiors that is used in the windows and doors. The material that is often used in this interior is wood. Limitations of wood used to make the interior are therefore needed alternative materials used in making this interior.

The composition of the sandwich from the material foams can increase the absorption of the impact energy of the structure.

Vaziri, A. et al [1] have conducted research on layered panel structures of material foams. The layered board structure design shows a significant effect on absorption of impact energy. Qiao, P. and Bibienda, W.K [2] have reviewed impact energy absorbing materials. The results of [2] review showed that the structural design of foams material influences the absorption of impact energy. Badri, M. et al [3] have conducted research on the polymeric foam response to impact loading. The results obtained by [3] show that polymeric foam is effective in absorbing impact energy. Badri, M. et al [3] concluded that the design of polymeric foam material products has structural stability subjected to impact loading. Ramakrishnan, K.R. et al [4] have compared differences in density of foam material in layered structures. This results show that foam material with a lower density can absorb more energy than a higher density. The treatment of fibers is useful for increasing the strength of composite materials. Pratama, Y.G. et al [5] have researched boiling coco fiber with NaOH. The boiling of fiber for 2 hours increases tensile strength more than boiling for 1 hour and 3 hours. Research conducted by [5] with the technique of soaking coconut fiber into 5% NaOH for 1 hour, 2 hours, 3 hours, and 4 hours is useful to remove the typical layer on coconut fibers. The results of tensile testing showed the highest tensile strength was obtained in the composite with soaking coco fiber for 2 hours. Izani, M.A.N. et al [6] the treatment of OPEFB fiber with boiling water for 30 minutes has fiber with a higher binding ability than soaking with NaOH. Izani, M.A.N. et al [6] performed 2% NaOH reduction for 30 minutes, boiling water for 30 minutes, and soaking and boiling 2% NaOH for 30 minutes. Izani, M.A.N. et al [6] concluded that boiling water for 30 minutes produced the highest shear modulus and elastic modulus than 2% NaOH immersion for 30 minutes and soaking and boiling 2% NaOH for 30 minutes. Choh, J.L. et al [7] examined the chopping process of OPEFB fibers using chopped techniques to increase the electrical conductivity of OPEFB fiber composites. Choh, J.L. et al [7] examined the chopped technique of OPEFB fibers with variations in volume of 0%, 5%, 10%, and 15% to increase the surface roughness of OPEFB fibers. Fiber chopping carried out by [7] increased electrical conductivity and thermal conductivity.

Based on the description above, it is necessary to investigate the effects of OPEFB fiber treatment on mechanical behavior of polymeric composite-OPEFB fiber sandwich composite panels. In this study, variations in treatment of OPEFB fibers, time chopping of OPEFB fibers, and chopping method will be seen in their effect on the tensile strength, impact value, microstructure of OPEFB fibers reinforced composite.

2.0 EXPERIMENTAL METHOD

2.1 Specimen preparation

Polyester resin is used as a matrix in making composites. The polyester resin used is Eternal 2250 resin with MEKPO catalyst as hardener. Polymeric Foam is used as a sandwich between 3 laminates from a composite plate before laminates combine into 1 specimen.

Figure 1 shows the OPEFB fiber. OPEFB fiber used in the manufacture of this composite is yellow OPEFB fiber with a length of 10 mm fiber.

Figure 1: OPEFB fiber

The OPEFB that has been obtained then takes the OPEFB fiber by chopping it and separating it from the empty palm fruit bunches. The separated OPEFB fibers were treated with 3 methods. Method 1 OPEFB fiber is boiled with distilled water with a temperature of 50ºC for 30 minutes. Method 2 OPEFB fiber soaked with 5% NaOH solution for 2 hours. Method 3 OPEFB fiber is boiled with 5% NaOH solution for 30 minutes with a temperature of 50ºC. Figure 2 shows the process of boiling the OPEFB fiber. The boiling process of OPEFB fiber by boiling OPEFB fiber in distilled water and NaOH solution.

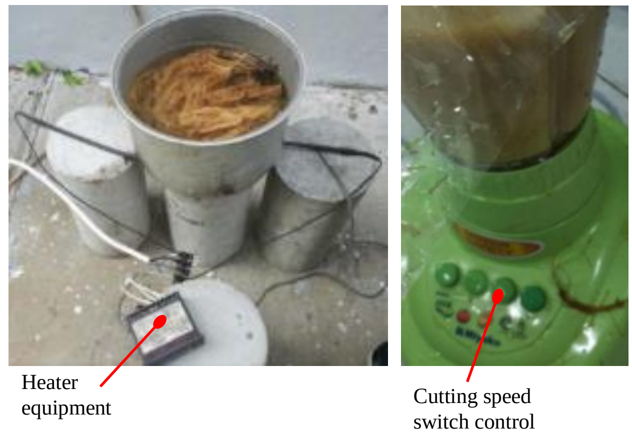

Figure 2: OPEFB fiber boiling and chopping equipment

The boiling process of OPEFB fibers using heater equipment connected to electricity. Boiling of OPEFB fiber is carried out after the temperature reaches 50ºC which is set on the thermostat and carried out for 30 minutes.

The first fiber treatment, fiber boiled with distilled water at a temperature of 50ºC for 30 minutes. The second fiber treatment was boiled with 5% NaOH solution at a temperature of 50ºC for 30 minutes. The third fiber treatment, the fiber was soaked with 5% NaOH solution for 2 hours. Furthermore, OPEFB fibers were chopped with a chopped machine at 1280 rpm rotation speed and 2560 rpm rotation speed for 1 minute, 2 minutes and 3 minutes. After chopping the fiber is dried in a fiber drying machine.

Figure 3 shows the OPEFB fiber that has been subjected to the treatment and drying process. The percentage determination of OPEFB fiber water content is based on SNI7652.3.2.2011.

Figure 3: Dried OPEFB fiber

The OPEFB fiber that has been dried is measured by water content by measuring the initial weight of the fiber. Furthermore,

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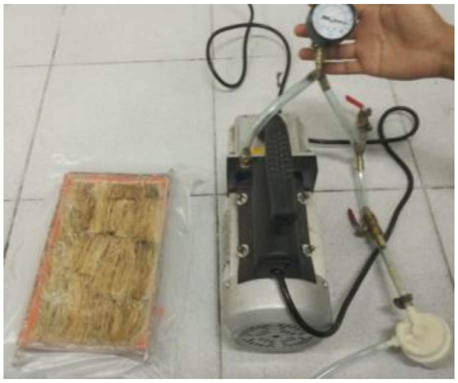
the fiber was heated in the oven and measured by the weight of the OPEFB fiber after heating using an oven for 1 hour. Furthermore, the weight of the fiber is measured again and heated using an oven until the weight of the fiber is constant.

After OPEFB fiber is prepared, then composite plate manufacturing is carried out. Figure 4 shows the composite plate manufacturing process with the vacuum assisted resin infusion method. The installation of a hose that is connects between the resin bucket and the mold and the resin trap up to the vacuum pump. Vacuum pump pressure is adjusted by closing the inlet channel and adjusting the control valve opening to adjust the pressure. The pointer on the manometer until it moves shows the pressure scale number to be used in this study. The vacuum pressure used is 6 mmHg.

a. vacuum molding



b. Specimen and vacuum pump

Figure 4: Vacuum assisted resin infusion

After the composite is vacuumed the mold is left to dry until the composite is dry and can be removed from the mold. Composites that have been removed from the mold are cut and finished using specific grinding until the composite has a thickness of 2 mm. The composite cutting process is carried out based on the standard tensile test specimen and impact test. The composite that has been cut is merged 3 into 1 laminate with foam material as a sandwich structure. Furthermore, composites that have become composite sandwich panels are carried out by finishing the polishing machine. After polishing, a composite specimen was obtained based on the composite test standard.

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

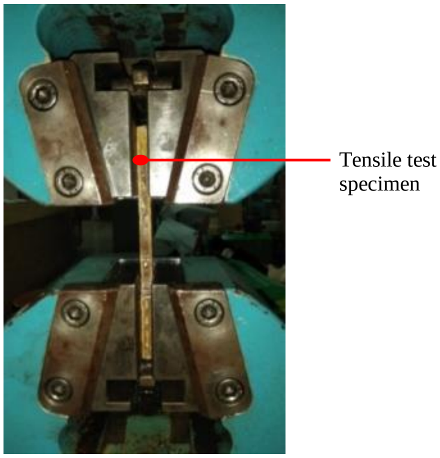


Figure 5: Setup of tensile test specimen (ASTM D 638-02)

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.

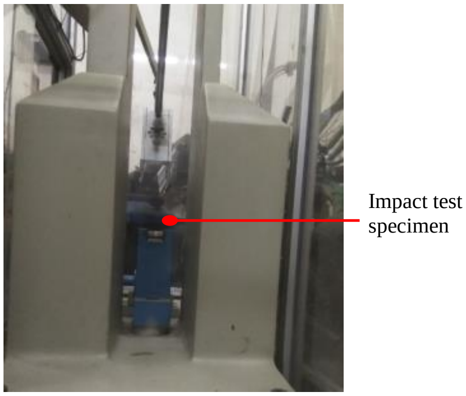


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Figure 6: Setup of impact test specimen (ASTM D 638-02)

The microstructure was observed using scanning electron microscope (SEM) observation in order to better understand damage mechanism. SEM observation on fracture surface can provide important information for research and development as well as fracture analysis. Samples for SEM have to be prepared to withstand the vacuum conditions and high energy beam of electrons, and have to be of a size that will fit on the specimen stage. Samples are generally mounted rigidly to a specimen holder or stub using a conductive adhesive. The morphological characterization of the composite surface is observed in scanning electron microscope of TESCAN VEGA3.

3.0 RESULTS AND DISCUSSION

3.1 Tensile strength

Figure 7 shows the tensile strength of the composite at boiling conditions of OPEFB fiber in distilled water at 50˚C for 30 minutes, where the tensile strength is not affected by the time of chopping at a rotation speed of 1280 rpm. In this round, the tensile strength showed a correlation of 0.5108 to the time of OPEFB fiber chopping. Whereas at a rotation speed of 2580 rpm it was found that the tensile strength correlations with the fiber chopping time were 0.7739.

Tensile strength of OPEFB fiber composites with fiber treatment by boiling fiber using distilled water at 50˚C for 30 minutes with chopping OPEFB fibers at 1280 rpm rotation speed has no effect on composite tensile strength. However, with a rotation speed of 2580 rpm for fiber treatment, the tensile strength of the OPEFB fiber reinforced composite is decreased.

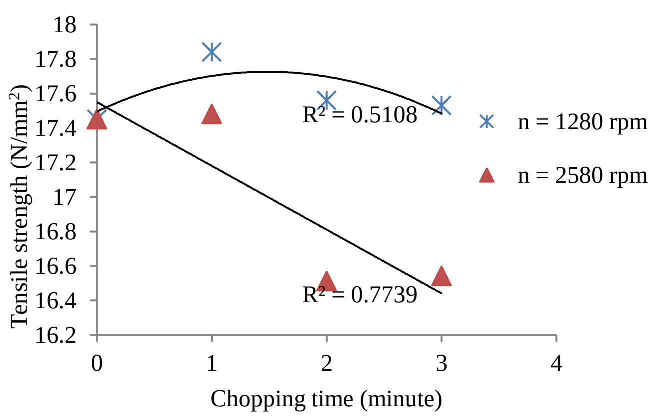

Figure 7: Effect of OPEFB fiber chopped on tensile strength in OPEFB fiber boiling in distilled water

Figure 8 shows the tensile strength of composite at OPEFB fiber soaking conditions in 5% NaOH solution for 2 hours with the chopping process at 1280 rpm rotation speed of the fiber counting process decreases the tensile strength with the coefficient of determination R^2 of 0.9245. At a condition of rotation speed of 2580 rpm, tensile strength has decreased with a correlation to the time of chopped OPEFB fiber of R^2 of 0.999. Figure 8 shows that in the fiber soaking condition with 5% NaOH for 2 hours with the chopping process at a rotation speed of 1280 rpm and 2580 rpm, it can reduce the tensile strength proportional to the addition of the chopping time with a coefficient of determination, R^2 over 0.9.

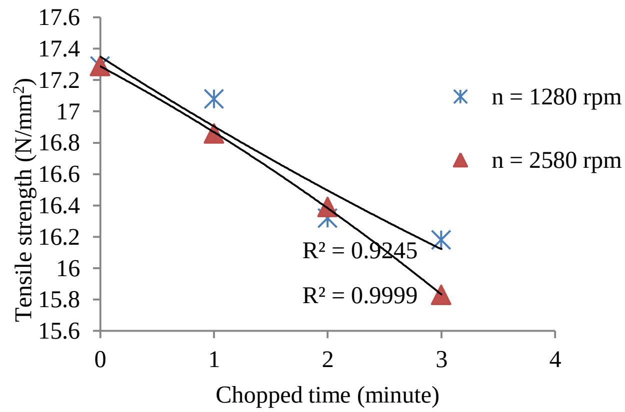

Figure 8: Effect of OPEFB fiber chopped on tensile strength in OPEFB fiber soaking in NaOH solution

Figure 9 shows the tensile strength of the composite under boiling conditions with a 5% NaOH solution. The process of chopping OPEFB fibers at a rotation speed of 1280 rpm is almost not affected by the time of chopping. Figure 9 shows the tensile strength of OPEFB fiber composites with boiling fiber treatment using 5% NaOH solution for 30 minutes at a temperature of 50˚C at 1280 rpm rotation speed, fiber chopping has no effect on tensile strength, while at a rotation speed of 2580 rpm fiber has an effect decrease the tensile strength of OPEFB fiber reinforced polymer composites.

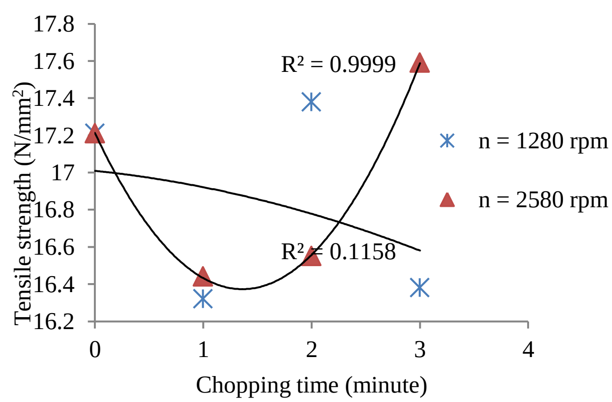

Figure 9: Effect of OPEFB fiber chopped on tensile strength in OPEFB fiber boiling in NaOH solution

Figure 10 shows the tensile strength with the chopping process at a rotation speed of 1280 rpm with 3 OPEFB fiber

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treatment conditions. The tensile strength of the composite in the treatment conditions of OPEFB fiber boiling in distilled water at 50˚C for 30 minutes by counting for 1 minute is higher than the tensile strength of the composite with the treatment soaked or boiled in NaOH solution.

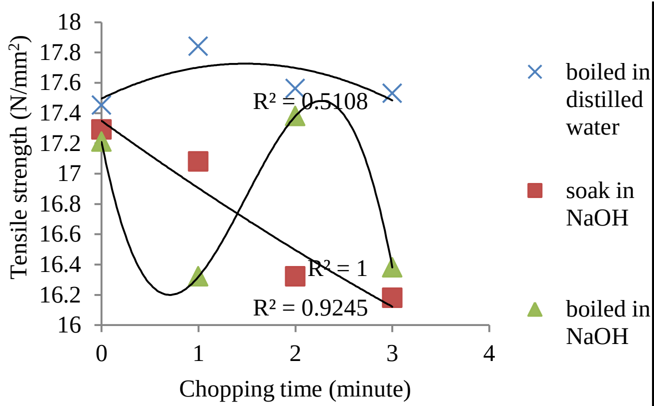

Figure 10: Effect of OPEFB fiber treatment on tensile strength at 1280 rpm

Figure 11 shows the tensile strength of OPEFB fiber polymer composites with the chopping process at a rotation speed of 2580 rpm with 3 fiber treatment conditions. The tensile strength of the composite with boiling fiber treatment in 5% NaOH solution at a temperature of 50˚C for 30 minutes with a chopping time for 3 minutes is higher than the tensile strength of the composite with the treatment of fiber boiled in distilled water and soaked in NaOH solution where the chopped speed is 2580 rpm.

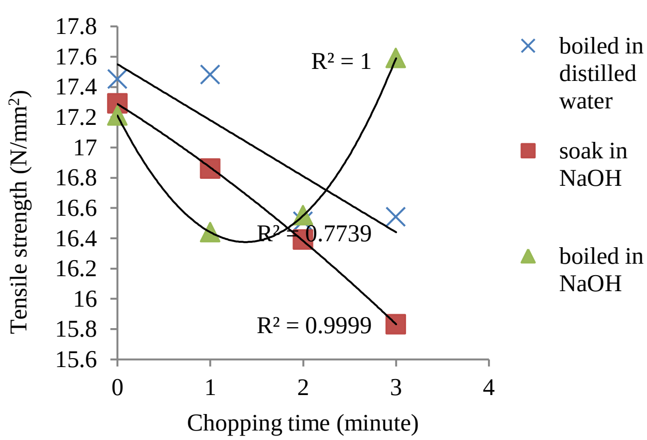

Figure 11: Effect of OPEFB fiber treatment on tensile strength at 2580 rpm

3.2 Impact value

Figure 12 shows the impact value of the composite in the treatment of OPEFB fiber boiling in distilled water at 50˚C for 30 minutes. The treatment of OPEFB fiber chopping at the cutting speed of 1280 rpm affects fiber increasing the higher impact value, even though the impact value decreases in the increase in chopping time with the determination coefficient is 0.9622.

The treatment of OPEFB fiber chopping at a speed of 1280 has [redacted]btained a higher impact value than 2580 rpm. The time of [redacted]hopping for 1 minute will result in a higher impact value [redacted]ompared to the longer chopping time. An analysis can be given [redacted]o the impact data obtained, where the boiling treatment in [redacted]PEFB fiber distilled water will decrease due to impact loading if [redacted]he speed and timing of OPEFB fiber chopping are increased.

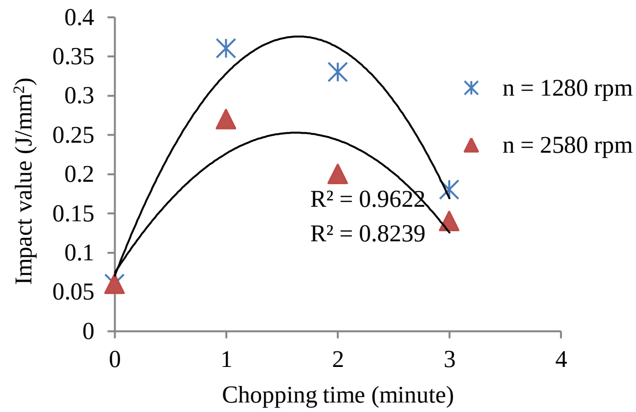

Figure 12: Effect of OPEFB fiber chopped on impact value in OPEFB fiber boiling in distilled water

Figure 13 shows the impact value of the composite under immersion conditions of OPEFB fiber in 5% NaOH solution for 2 hours. In the chopping treatment at a rotation speed of 1280 rpm OPEFB fiber composites experience a trend of decreasing the impact value in proportion to the time of chopping fibers with a coefficient of determination of 0.6. In the treatment of fiber chopping 2580 rpm the impact value is lower than 1280 rpm. This is caused by higher chopping which results in OPEFB fibers decreasing the propagation of impact energy.

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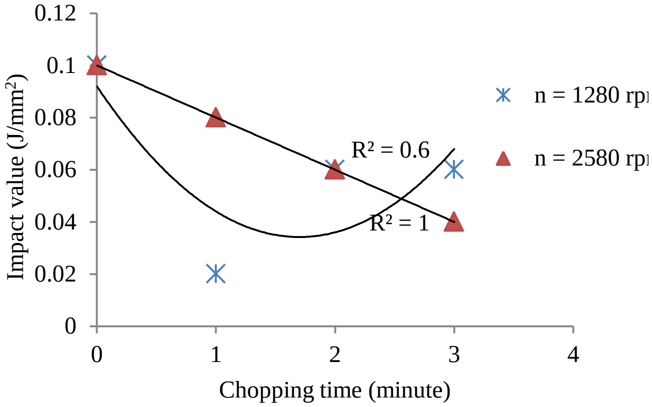

Figure 13: Effect of OPEFB fiber chopped on impact value in OPEFB fiber soaking in NaOH solution

Figure 14 shows the impact values of OPEFB fiber polymer composites with boiling fiber treatment in 5% NaOH solution. For the treatment of OPEFB fiber chopping at a speed of 1280 rpm it was obtained that it did not show an effect even though the chopping time increased where the coefficient of determination was 0.427. For the cutting speed of 2580 rpm it also does not show a significant effect on the impact value obtained.

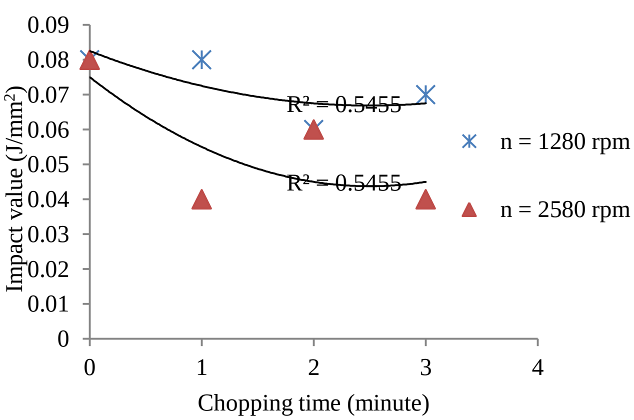

Figure 14: Effect of OPEFB fiber chopped on impact value in OPEFB fiber boiling in NaOH solution

Figure 15 shows the impact values of polymeric foam composites reinforced by OPEFB fibers where the treatment is chopped at a speed of 1280 rpm with 3 fiber treatments. From Figure 14, it was found that the impact value of boiling fiber treatment in distilled water at 50˚C for 30 minutes by counting for 1 minute was higher than the impact value of the composite with fiber treatment soaked and boiled in NaOH solution. The impact value of the composite with the boiling treatment of fiber in distilled water was 50˚C for 30 minutes with decreased fiber chopping due to the increase in chopping time.

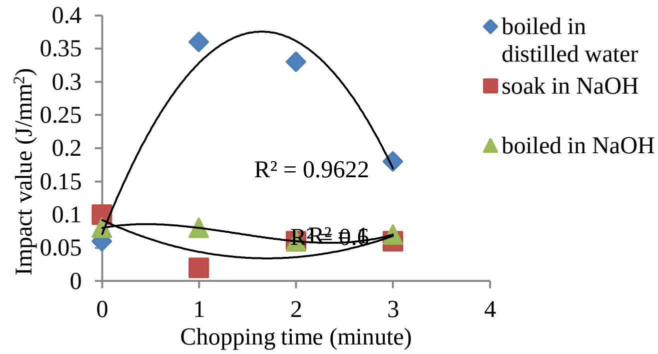

Figure 15: Effect of OPEFB fiber treatment on impact value at 1280 rpm

Figure 16 shows the impact value with the chopping process at a rotation speed of 2580 rpm with 3 OPEFB fiber treatment conditions. The highest impact value on the boiling treatment of fiber is distilled water at 50˚C for 30 minutes with chopping for 1 minute.

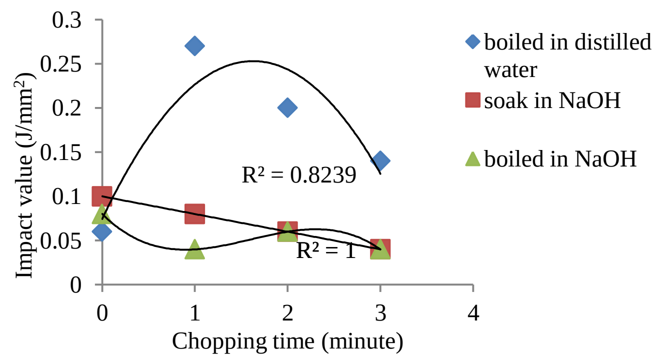

Figure 16: Effect of OPEFB fiber treatment on impact value at 2580 rpm

For chopping conditions to obtain a higher impact value, the fiber from OPEFB is chopped in an interval of less than 1 minute so that the OPEFB fiber surface is still able to strengthen the interface bond with the composite matrix which is subjected to impact loading.

3.3 SEM Observation

Figure 17 shows the failure of OPEFB fiber with the treatment of boiled fiber in distilled water. The OPEFB fiber debonding failure subjected to tensile loading. The coarser surface of the OPEFB fiber will bond to the interface with the matrix. Treatment of fiber by boiling in distilled water increases the surface roughness of the fiber where the fiber cutting speed is 1280 rpm.

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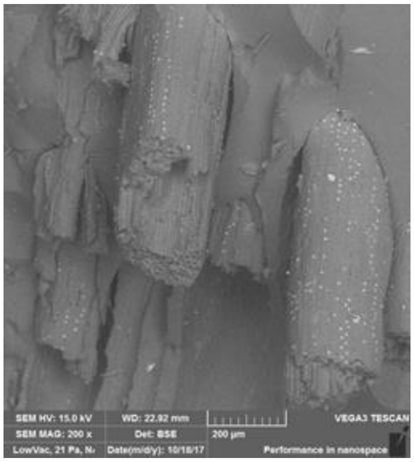

Figure 17: SEM of OPEFB fiber boiling in distilled water treatment at 1280 rpm

Figure 18 shows the failure of OPEFB fibers subjected to tensile loading where the fiber treatment is boiled in distilled water. The condition of fiber debonding at a cutting speed of 2580 rpm indicates a failure of the polymer matrix, the failure of the OPEFB fiber interface and matrix is almost visible.

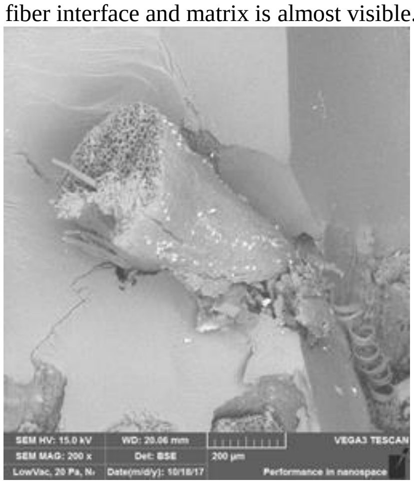

Figure 18: SEM of OPEFB fiber boiling in distilled water treatment at 2580 rpm

Different failures can be found in composites where OPEFB fiber treatment is boiled in distilled water. Composites with fiber treatment soaked and boiled in NaOH solution showed a decrease in OPEFB fiber interface bonding and matrix polymer. Figure 19 shows the failure of OPEFB fibers subjected to tensile loading. OPEFB fiber with treatment was immersed in NaOH solution and chopped at 1280 rpm.

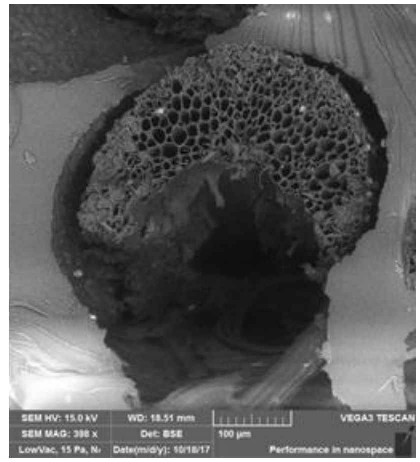

Figure 19: SEM of OPEFB fiber soaking in NaOH solution treatment at 1280 rpm

Figure 20 shows the failure of polymeric foam composite OPEFB fibers subjected to tensile loading, the treatment of OPEFB fibers was carried out by boiling in NaOH solution, chopped at 2580 rpm. Failure of OPEFB fibers with fiber treatment soaked in NaOH solution reduces the fiber interface bond with the polymer matrix. On the surface of the OPEFB fiber, matrix and polymeric foams are found in the residual fiber material which is not useful at certain levels so as to reduce the bond on the fiber surface.

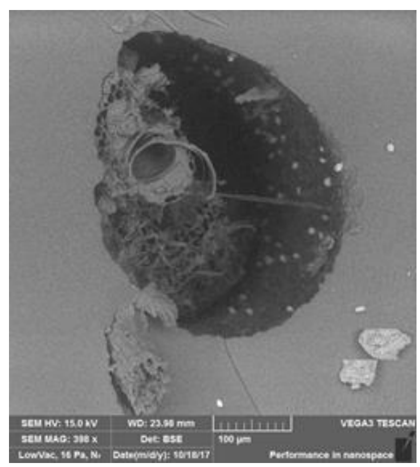

Figure 20: SEM of OPEFB fiber soaking in NaOH solution treatment at 1280 rpm

Figure 21 shows the failure of OPEFB fibers from polymeric composite materials to be subjected to tensile loading with fiber treatment boiled in NaOH solution and chopped at 1280 rpm. Failure of OPEFB fibers is found as pull out of the polymer matrix. The boiling treatment of fiber in NaOH solution has not completely eliminated impurities that are not expected on the surface of the OPEFB fiber.

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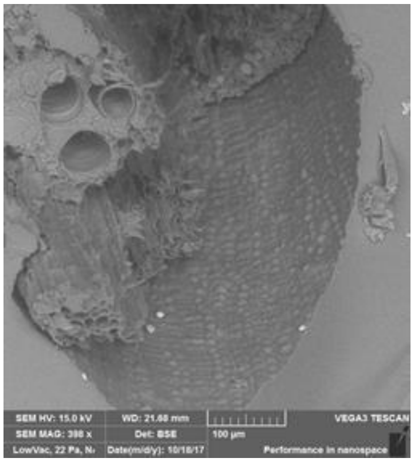

Figure 21: SEM of OPEFB fiber boiling in NaOH solution treatment at 1280 rpm

Figure 22 shows the failure of OPEFB fibers treated with boiled in NaOH solution and chopped at 2580 rpm. From SEM observations it is known that there is a shift in the surface of the fiber and matrix. Photograph shows that fiber has optimally responded to the load distributed to each fiber, but the fiber bond has plastic deformation where the fiber is like pull out. However, it is observed from the failure found fiber is pulled from the matrix.

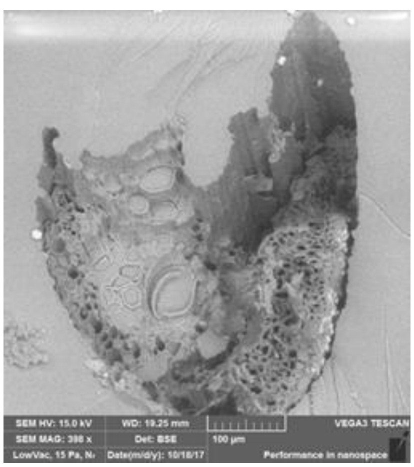

Figure 22: SEM of OPEFB fiber boiling in NaOH solution treatment at 2580 rpm

4.0 CONCLUSION

This work has reported the effect of OPEFB treatment on the mechanical behavior of polymeric foams-OPEFB fiber sandwich panels composite. The obtained summaries are as follows: (1) tensile strength and impact value of polymeric composite-OPEFB fiber sandwich composite panels are influenced by the fiber treatment method. In this work, tensile strength and impact of composite with OPEFB fiber boiled in water 50^{o}C higher than other fiber treatments. (2) The time and speed of fiber chopping influence the tensile strength and impact of polymeric composite-OPEFB fiber sandwich composite panels. tensile strength and impact decreases with increasing time and speed of cutting tools on OPEFB fiber chopping.

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