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GSJ: Volume 8, Issue 11, November 2020, Online: ISSN 2320-9186 www.globalscientificjournal.com WATER ABSORBTION OF POLYESTER COMPOSITE SANDWICH REINFORCED CANTULA FIBER AND BANANA STEM FIBER WITH CORN COB CORE Sujita Darmo1, Rudi Sutanto2 1,2Faculty of Engineering, Departmen of Mechaical Engineering Mataram University, Mataram, Indonesia. E-mail: 1sujita@unram.ac.id, 2r.sutanto@unram.ac.id ABSTRACT The Water absorption behavior of sandwich structures composed of polyester reinforced cantula fiber and banana stem fiber face sheets bonded to a corn cob core is examined here in. The volume fraction of cantula fiber are 0 %, 5 %, 10 %, and the volume fraction of banana stem fiber are 15 %, 20 % and 30 %..The size of specimens in this study is the length of 80 mm, a width of 80 mm and a thickness of 12.7 mm for the skin and core size corncob 30 mm, according to standard ASTM C – 272. The test was carried out by the density test and swelling test, to measure the volume of the composite using a caliper with an accuracy of 0.05 mm. The results showed that the water absorption of the composites was indicated by changes in weight, swelling and density of the specimen. Water absorption is influenced by fiber volume fraction, fiber direction, fiber type and the interaction of these three factors. Water absorption is more dominantly influenced by the direction of the fiber than other factors. The biggest water absorption occurred in the volume fraction of 30% banana stem fiber and 10% cantula fiber with woven direction. The percentage of water absorption is 38.86% to 33.69%. Likewise, the highest swelling occurred in composite sandwich with the same volume fraction, but with unidirectional fiber direction, namely 16.45% for banana stem fiber and 11.02% for cantula fiber. In contrast to the composite gravity, the smallest value volume fraction was 18.61% for banana stem fiber and 19.93% for cantula fiber. . . Keywords: composite sandwich, core, polyester, Corncob, cantula fibers, banana stem fibers, water absorption. INTRODUCTION The material sandwich composite is a composite material consisting of two skins, between the two skins there is a core that is joined together with adhesive to withstand the shear forces between the skin and the core so that the strength of the sandwich is stable. (Aviles, et al. 2009). Skin functions to withstand tensile and compressive stress. Skin has low stiffness. Conventional skins are metals such as aluminum, stainless steel. Polyester resin material reinforced with fiberglass fiber is the best skin material because it has advantages such as being easy to combine, the design can be adjusted according to the needs, good surface shape. The core is one of the most important parts of the sandwich, it needs to be rigid enough to keep the gaps between the surfaces. The core must be able to withstand shear forces to prevent slides between surfaces. The core material must be strong, have high stiffness, low density, long life and also other requirements, such as moisture content, and buckling. The water absorption property is very important to get attention so that the sandwich composite material has a long wear resistance. The recent years, the The water absorption properties of the material sandwich composite has been diligently studied. In the research carried out by Aviles, et al. (2009). The hygroscopic behavior of sandwich structures composed of E-glass/polyester face sheets bonded to a PVC foam core ex- posed to 95% relative humidity and immersed in sea water is examined herein. Moisture uptake was monitored for 11 months yield- ing absorption curves for samples of polyester resin, laminated composites, PVC foam core, and a sandwich structure. The coeffi- cients of diffusion and moisture saturation values extracted from the curves are significantly greater for the water immersed condi- tion than for the exposed to elevated moisture one, and point to the foam core as the most absorbing material in the sandwich structure. The measured absorption curves are compared to a diffusion model which employs the calculated coefficient of diffusion, showing good agreement. Mohamed, et al., (20130, have done researched obout moisture effects on performance of polyurethane composite sandwich panels manufactured using VARTM. The sandwich structures composed of woven E-glass reinforced polyure- thane facesheets and polyurethane rigid foam core were fabricated using Vacuum Assisted Resin Transfer Molding (VARTM) process. The specimens were immersed in distilled water at room temperature. Flexure and low velocity impact tests were conducted for both dry and wet samples to investigate the mechanical degradation due to moisture uptake. Dynamic three dimensional modeling was developed to study the moisture effect on the impact behavior under the energy level 30 J and finite element simulation results were validated with experimenal findings. The other research, Huo, et al., (2018), This study investigated the effect of moisture ab- sorption on the mechanical performance of polyurethane sandwich composites. The core material was a closed cell polyurethane foam. Face sheets were made of E-glass/polyurethane composite laminates. Vacuum-assisted resin transfer molding process was used to manufacture specimens for testing. The foam core, laminates, and sandwich composites were submerged in salt water for prolonged periods of time. Mechanical property degradation due to moisture absorption for each constituent was evaluated. Com- pression test was performed on the foam core samples. Laminates were evaluated by three-point bending tests. The interfacial bond strength in the sandwich structure was evaluated by double cantilever beam mode-I interfacial fracture test. The testing results re- vealed that the effect of salt water exposure on the compressive properties of the foam core is insignificant. The flexural modulus of polyurethane laminates degraded 8.9% and flexural strength degraded 13.0% after 166 days in 50% salinity salt water at 34°C condi- tioning. The interfacial fracture toughness of polyurethane sandwich composites degraded 22.4% after 166 days in 50% salinity salt water at 34°C conditioning. In the work, he concluded that After 30days of exposure to high moisture, foam damage is visible in the form of cracks and pits on the cell walls. Optical examinations of expansional strains show that moisture absorbed by the foam pene- trates only about to 2–3mm from the core free surface for the 95% RH condition, while penetrates deeply for the immersed condi- tion. (Aviles, et al. 2009). Test results have shown that hygrothermal environment condition has a severe effect on the compressive strength of laminates and the reduction in compression strength for stitched laminates reached up to 50%. Stitching might improve the compressive strength of laminates depending upon the environmental conditions and lay-up sequence of stitched laminates, Xiaoquan, et al., (2011). Based on the description, research on water absorption on sandwich composite material with skin reinforced with natural fibers and cores from agricultural waste has not been carried out. The objective of this researched, the material composite sandwich, with skin structures composed of polyester reinforced cantula fiber and banana stem fiber and core are corn cob . MATERIALS AND METHODS FOR EXPERIMENT The material composite sandwich used in this study consisted of skins and cores. Skin in the form of polyster which is reinforced with cantula and banana stem fiber , core are corn cob. The volume fraction of cantula fiber are 0 %, 5 %, 10 %, and the volume frac- tion of banana stem fiber are 15 %, 20 % and 30 %. The process of taking fiber is done by soaking the cantula leaves for a week and banana stems for 2 days then dredging, drying at room temperature or aerating. The fibers were immersed in 4% NaOH solution by volume for 2 hours. The length of the fiber is 20 mm (random fiber) and 80 mm (unidirectional and woven fiber). The skin mold is made using plate iron with a thickness of 12.7 mm with a printing area of 80 mm x 80 mm. The corncob cores are made with a diameter of 20 mm and a thickness of 30 mm. Making a composite sandwich by gluing the skin and core using polyester resin.The size of specimens in this study is the length of 80 mm, a width of 80 mm and a thickness of 12.7 mm for the skin and core size corncob 30 mm, according to standard ASTM C – 272, are shawn at Figure 1 . The test was carried out by the density test and swelling test, to meas- ure the volume of the composite using a caliper with an accuracy of 0.05 mm. The Skin 12,7 mm 30 mm The Core 12,7 mm 80 mm 80 mm Figure 1. The water absorption test specimen standard ASTM C – 272 Water absorption analysis with equations 1 to 4 : $a.\ Warer\ aarlraril = w100$ %..(1) W = Wet weight (gr) D = Dry weight (gr) b. $Swellilg = w100$ %...(2) v = initial volume (mm3) v = final volume (mm3) c. $\rho = (gr/ll$)...(3) d. $\Delta\rho = w$ 100 %...(4) m = mass (gr) v = volume (mm3) ρ = initial density (gr/mm3) ρ = final density (gr/mm3) RESULT AND DISCUSION Water Absorption Test Results The water absorption test was carried out by immersing the test specimen for 7 x 24 hours at room temperature. The sandwich composites were weighed before and after immersion with a digital scale with an accuracy of 0.01 grams. The test was repeated three times. The data from the water absorption test results in a graph of the relationship between variations in the volume fraction of fiber and fiber direction to the water absorption of the sandwich composite, as shawn in Figure 2. And Figure 3. In the water absorption test of sandwich composites with polyester skin reinforced with banana stem fiber, there is a difference with the cantula fiber, where in each volume fraction of the fiber has a different water absorption value. This indicates that there is an effect of variation in fiber volume fraction on water absorption. In Figure 2, it is shown that the composite without fiber or 0% has the smallest water absorption value, namely 25.07%, while the largest water absorption value occurs at a volume fraction of 30%, namely 38.86% in sandwich composites with skin fiber reinforced polyester bananas with woven fiber direction, as well as cantula fibers by 33.69% in the same volume fraction and fiber direction (Figure 3.). Therefore the fiber volume fraction affects the composite water absorption, the more fiber is added, the more water absorption will increase. Composites with random fiber directions absorb less water than unidirectional or woven fiber directions, because composites with random fiber directions have short fibers and are not completely connected to other fibers, so that the water infiltration in the composites does not spread to the other fibers. The water absorption value of random fiber sandwich composites at a volume fraction of 30% was 29.24% for banana stem fiber and 30.15% for cantula fibers at the same volume fraction. The change in weight in the composite indicates the presence of water absorption in the composite due to the effect of immersion. At the time of immersion, water will seep and stick to the core and the composite skin, thereby increasing the weight of the composite. The Wa P t e e n ry A er b a s p o a rn bti A o ir n (% %) 40,00 38,00 BSF W 36,00 34,00 BSF UD 32,00 30,00 28,00 26,00 BSF R 24,00 0% 5% 10% 15% 20% 25% 30% The Fiber Fraction Volume (%) Figure 2. The water absorbtion material composite sandwich with skin banana stem fiber PT en hy eer W aa pt a e n rA Ai b rs(or %) btion % 36,00 34,00 32,00 30,00 28,00 CF W CF UD CF R 26,00 24,00 0% 5% 10% 15% 20% 25% The Fiber Fraction Volume (%) 30% Figure 3. The water absorbtion material composite sandwich with skin cantula fiber The Swelling Test Results The tests are carried out using a caliper to measure changes in the volume of the composite. The test specimens were immersed for 7 x 24 hours at room temperature. The test specimens were measured before and after immersion with a caliper with an accuracy of 0.05 mm. The test was repeated three times. From the swelling test results of the polyester sandwich composite of banana stem fiber and cantula fiber, a graph of the relationship between variations in fiber volume fraction and fiber direction of swelling of the sandwich composite was shown, as shown in Figure 4 and Figure 5.. Pembengkakan (%) 18,00 16,00 BSF W 14,00 The Swelling % 12,00 10,00 8,00 BSF UD 6,00 4,00 BSF R 2,00 0,00 0% 5% 10% 15% 20% 25% 30% The Fiber Fraction Volume of %) Figure 4. The swelling of material composite sandwich with skin banana stem fiber The Sw P el e li m n b g eng % kakan (%) 12,00 10,00 8,00 6,00 4,00 2,00 0,00 CF W CF UD CF R 0% 5% 10% 15% 20% 25% 30% The Fiber Fration Volume (%) Figure 5. The swelling of material composite sandwich with skin cantula fiber The swelling measurement of composites in water is related to the size stability of the composites when the composites are used outdoors exposed to rainwater or in extra humid environments. When the water sticks to the composite skin, the water flow into the composite can pass through the reinforcing fibers and be passed into the composite. Defects in making composites such as micro cracks, voids or air holes, and the anatomy of the composites which are capillary in nature can accelerate the absorption of water into the composite. From the measurement results of swelling in the volume of the sandwich composites in Figure 4, it shows that the sandwich composite reinforced with banana stem fiber experienced swelling when immersed, the highest swelling value was found in the variation of the volume fraction of banana stem fiber 30%, which was 16.45% in the direction of woven fibers. While the lowest swelling of the composites was found in the variation of the fiber volume fraction of 0% or without the addition of fiber, which was 1.20%, the swelling value of the composite continued to increase with the increase in fiber volume fraction. This also occurred in sandwich composites with skin reinforced with cantula fiber (Figure 5.) with the direction of woven fibers at a volume fraction of 5% by 2.54% and continued to increase until the greatest swelling occurred at a volume fraction of 30% by 11.02% in this

direction. the same fiber. This shows that the fiber volume fraction affects the swelling of the composite, because the fiber absorbs more water than the composites matrix. The tendency of sandwich composite swelling has decreased because the water that enters the composite with the random fiber direction does not interact too much between one fiber and another. The lowest swelling value was 5.79% for banana stem fiber at a volume fraction of 30% and pineapple fiber at 7.63% in the same volume fraction. CONCLUSION The Sandwich composites with polyester skin reinforced by banana stem fiber absorb more water than cantula fibers, because banana stem fibers have hygroscopic properties compared to cantula fibers. Based on ANOVA analysis, fiber volume fraction, fiber direction, fiber type and the interaction of the three variation factors affect water absorption, but water absorption is more dominantly influenced by the direction of the fiber. The highest water absorption value occurred in sandwich composites with polyester skin reinforced with banana stem fiber, a volume fraction of 30%, in the direction of woven fiber, namely 38.86% and 33.69% for cantula fibers at the same volume fraction and fiber direction. The highest swelling value also occurred in the fiber volume fraction of 30% with the direction of woven fibers, namely 16.45% for banana stem fiber and 11.02% for cantula fiber. The greater the fiber volume fraction in the composite, the greater the swelling value of the composite. Conversely, the greater the fiber volume fraction in the composite, the smaller the density value will be. The smallest specific gravity value occurs in the variation of the volume fraction of 30% fiber with unidirectional fiber direction, namely with a value of 18.61% for banana stem fiber and 19.93% for cantula fiber. ACKNOWLEDGMENT The authors thank Prof. Rudy Soenoko, Prof. Wahyono Suprapto are acknowledged for invaluable endless collaboration. Prof. I.G.N Wardhana Director Postgraduated Doctor Mechanical Engineering Program Brawijaya University permission to use of laboratory and other resource materials. References. [1] Aviles, Francis & Aguilar-Montero, M.. (2009). Moisture absorption in foam-cored composite sandwich struc- tures. Polymer Composites. 31. 714 - 722. 10.1002/pc.20872. [2] Mohamed, Mohaned & Huo, Zhen & Hawkins, S. & Chandrashekhara, K. & Birman, V. & Volz, Jeffery. (2013). Moisture effects on performance of polyurethane composite sandwich panels manufactured using VARTM. Inter- national SAMPE Technical Conference. 1068-1081. [3] Huo, Zhen & Mohamed, Mohaned & Nicholas, JR & Anandan, Sudharshan & Chandrashekhara, K. (2018). Effect of salt water exposure on foam-cored polyurethane sandwich composites. Journal of Sandwich Structures & Materi- als. 22. 109963621878332. 10.1177/1099636218783328. [4] Aviles, Francis & Aguilar-Montero, M.. (2010). Mechanical degradation of foam-cored sandwich materials ex- posed to high moisture. Composite Structures. Compocite Structure.92.122-129. 10.1016/j.compstruct.2009.07.004. [5] Huo, Zhen & Anandan, Sudharshan & Xu, Mingzhi & Chandrashekhara, K. (2017). Investigation of three- dimensional moisture diffusion modeling and mechanical degradation of carbon/bismaleimide composites under seawater conditioning. Journal of Composite Materials. 52. 002199831772515. 10.1177/0021998317725159. [6] Xiaoquan, Cheng & Baig, Yasir & Zhonghai, Li. (2011). Effects of hygrothermal environmental conditions on compressive strength of CFRP stitched laminates. Journal of Reinforced Plastics and Composites - J REINF PLAST COMPOSITE. 30. 110-122. 10.1177/0731684410384894.. [7] Xiaoquan, Cheng & Baig, Yasir & Li, Zheng. (2012). Effects of Stitching Parameters on Tensile Strength of FRPs under Hygrothermal Conditions. Advanced Materials Research. 570. 63-77. 10.4028/www.scientific.net/AMR.570.63. [8] ZHENG, Yun & Xiaoquan, Cheng & YASIR, Baig. (2012). Effect of Stitching on Plain and Open-hole Strength of CFRP Laminates. Chinese Journal of Aeronautics. 25. 473–484. 10.1016/S1000-9361(11)60411-1. GSJ: Volume 8, Issue 11, November 2020 ISSN 2320-9186 785 GSJ: Volume 8, Issue 11, November 2020 ISSN 2320-9186 786
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