Journal of Physics: Conference Series

PAPER • OPEN ACCESS

Effect of Manufacturing Method to Tensile Properties of Hybrid Composite Reinforced by Natural (Agel Leaf Fiber) and Glass Fibers

To cite this article: A Nugroho *et al* 2018 *J. Phys.: Conf. Ser.* **1005** 012004

IOP Conf. Series: Journal of Physics: Conf. Series **1005** (2018) 012004 doi:10.1088/1742-6596/1005/1/012004

Effect of Manufacturing Method to Tensile Properties of Hybrid Composite Reinforced by Natural (Agel Leaf Fiber) and Glass Fibers

A Nugroho[1)] *, K Abdurohman[2)], Kusmono[1)], H Hestiawan[1)] and Jamasri[1)]

[1]) Department of Mechanical and Industrial Engineering, Faculty of Engineering, Gadjah Mada University,Jln. Grafika No. 2 Yogyakarta 55281, Indonesia
[2]) Aeronautics Technology Center - LAPAN, Indonesia
*afidnugroho83@gmail.go.id

Abstract. This paper described the effect of different type of manufacturing method to tensile properties of hybrid composite woven agel leaf fiber and glass fiber as an alternative of LSU structure material. The research was done by using 3 ply of woven agel leaf fiber (ALF) and 3 ply of glass fiber (wr200) while the matrix was using unsaturated polyester. Composite manufacturing method used hand lay-up and vacuum bagging. Tensile test conducted with Tensilon universal testing machine, specimen shape and size according to standard size ASTM D 638. Based on tensile test result showed that the tensile strength of agel leaf fiber composite with unsaturated polyester matrix is 54.5 MPa by hand lay-up and 84.6 MPa with vacuum bagging method. From result of tensile test, hybrid fiber agel composite and glass fiber with unsaturated polyester matrix have potential as LSU structure.

1. Introduction

Lembaga Penerbangan dan Antariksa Nasional (LAPAN) was developing unmanned aircraft called Lapan Surveillance UAV (Unmanned Aerial Vehicle - LSU. There were some kind of UAV developing by LAPAN such as LSU-01, LSU-02, LSU-03, and LSU-05. They have some missions such as air picture or mapping of certain region.

The main materials used for LSU-02, LSU-03, and LSU-05 are polymer matrix composit using glass or carbon fiber and epoxy or polyester resin. The fiber is synthetic fiber type like glass, carbon, and aramid that widely used in composite because of its high stiffness, strength, and light weight. The disadvantages of shyntetic fiber are weakness of biodegradability, high cost in manufacturing, recycle, energy consumsion, engine abrasion, and healthy hazard. It changes interest of synthetic to natural fiber.

The advantages of natural fiber are environmental friendly, low density, recycle ability, no toxic, low price, low energy consumsion, high specific mechanical properties, good non-abrassive and heat resistance [1]; [2]; [3]. The disadvantages of natural fiber are high humidity, water resistance properties, and not uniform size variation [4].

Development of natural fiber is widely used because of limited metal material source in the world [5]. Despite couldn't fully change synthetic fiber, the used of natural fiber is a wise step in environmental issue. One of Indonesian natural fiber is agel leaf fiber from gebang tree (Corypha gebanga). Its wide leaves are often used for traditional roof, and the fibers are used for producing traditional strings, bags, caps, chairs, and other handicraft.

Figure 1. Gebang tree

Mechanical properties of composite are influnced by several factors such as fiber type, matrix type, fiber to resin ratio, geometry, and fiber orientation [6]. There are 3 types of matrix; thermoplastic, thermoset, and elastomer. Widely used matrix is thermoset such as epoxy, polyster, and phenol resin [7]. The development of composite materials improving their performance limits based on the reinforcement of two or more fibres (synthetic fibre with another synthetic fibre or synthetic fibre with natural fibre or synthetic fibre with metallic fibres) in a single polymeric matrix, which leads to the advanced material system called hybrid composites with a great diversity of material properties, is still in its infancy [8].

The properties of a hybrid composite mainly depend upon the fiber content, length of individual fibres, orientation, extent of intermingling of fibres, fiber to matrix bonding and arrangement of both the fibres. The strength of the hybrid composite is also dependent on the failure strain of individual fibres. Maximum hybrid results are obtained when the fibres are highly strain compatible [9]. Fiber woven fabrics are probably the most commonly used textiles in structural applications [10]. This research use woven fabric glass fiber and hybrid by agel leaf natural fiber.

The objectives of this research is to know the influence of manufacturing method; hand layup and vacuum bagging in the manufacturing process of hybrid composite agel leaf fiber (ALF)/WR 200 glass fiber/unsaturated polyster in relationship to tensile properties.

2. Method

Manufacturing of hybrid composite woven ALF/WR 200 glass fiber/unsaturated polyster are used hand layup and vacuum bagging method. Braiding process of ALF are using simple machine. Braiding process are did in handicraft center of natural fiber in Sentolo, Kulonprogo, Yogyakarta. WR200 fiber glass and unsaturated polyester (UPRs) 157 BQTN with hardener MEKPO (metil etil keton peroksida) 1% are supplied by PT. Justus Kimia Raya Jakarta.

Fig. 2 showed the stacking sequence of hybrid composite consist of 6 layers of fiber (3 layers ALF and 3 layers WR200 glass fiber) where the laminate are ALF-FG-ALF-FG-ALF-FG. Hand layup used mould that refer to tensile test standard of ASTM D638 (see fig. 2). It used post processing by press. Vacuum bagging used release film and breather fabric to reserve resin during vacuum process. Vacuum bagging equipment are showed in fig. 3. Composite panel 100x170x2 mm is cutted to tensile test specimen refer to ASTM D638.

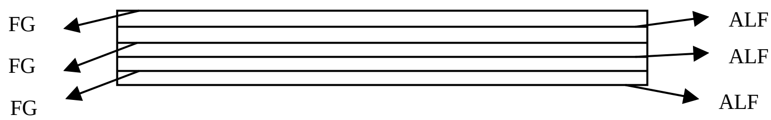

Figure 2. Stacking sequence of composite

Figure 3. Hand lay-up mould

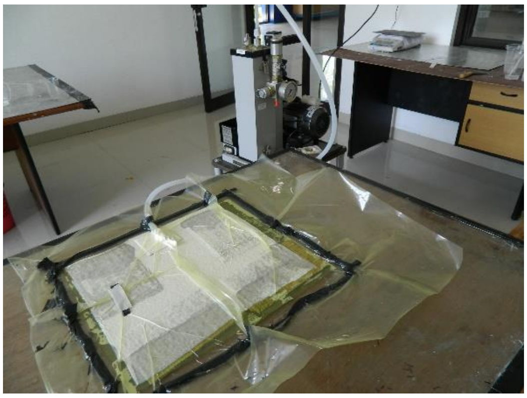

Figure 4. Vacuum bagging equipment

3. Results and Discussions

The result of manufacturing process showed the physic differences between hand layup and vacuum bagging, specially in composite thickness. With the same layer of fibers there are different thickness of composite wich are 3 mm for hand layup and 2 mm for vacuum bagging. Vacuum bagging utilized vacuum pressure during the process, so it pressed the laminates and partly resin come out from the laminate. It caused the vacuum bagging thickness lower than hand lay up. Otherwise, it described that the matrix fraction of vacuum bagging lower than hand layup (fiber fraction higher) because there are resin reduction during the process caused by vacuum pressure.

The tensile strength of both hand layup and vacuum bagging are presented in Fig. 5. It showed the ultimate strength for hand layup composite is 54.5 MPa and vacuum bagging composite 84.6 MPa. It showed that composite tensile strength using vacuum bagging 36% higher than hand layup composite. It was caused by higher fiber fraction in vacuum bagging as a result of vacuum process. K. Jarukumjorn and N. Suppakarn 2009 [11] have reported the properties of hybrid composite glass and sisal natural fiber–polypropylene. The best tensile strength for glass-sisal composite is 31.59 MPa. It means that tensile strength of glass-ALF-UPRs better than glass-sisal-PP composite. Other research by V.P. Arthanarieswaran et. al. 2014 [12] have reported the properties of banana fiber reinforced epoxy composite with glass fiber hybridization. It used the laminate variation of glass (G)/banana (B)/glass (G) and glass/banana/glass/banana/glass. The results showed the tensile strength are 46 MPa for G/B/G and 88 MPa for G/B/G/B/G. It indicated that the tensile strength of glass-ALF-UPRs higher than G/B/G-epoxy but lower than G/B/G/B/G-epoxy. This comparative tensile strength value could be suggestion to the next research of ALF hybrid composite with the upper and lower skin laminate using glass fiber to be symmetric balanced. It possible that the ALF skin of laminate become the first failure of the composite because the mechanical properties of ALF is lower than glass fiber.

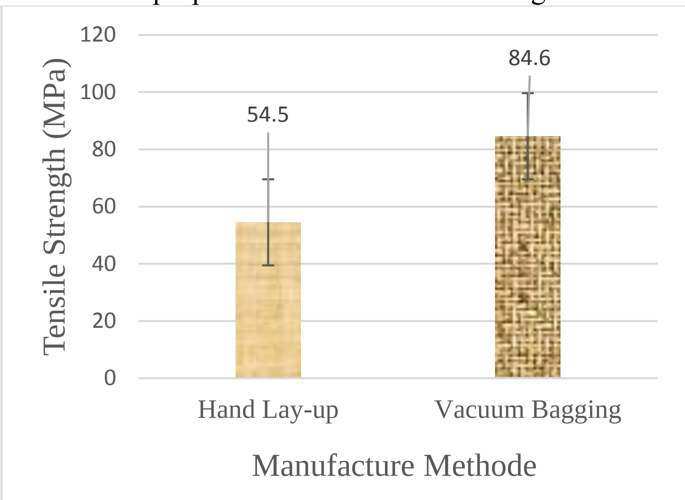

Figure 5. Ratio of manufacturing method to tensile strength

Fig. 6 presented the elastic modulus value for both vacuum bagging and hand layup composite. Elastic modulus value for hand layup composite is 3494.8 MPa and vacuum bagging composite 3046.1 MPa. It showed that vacuum bagging elastic modulus 13% lower than hand layup. Other research reported that elastic modulus is 2430 MPa for sisal-glass-PP [11] and 1940 MPa for banana-glass-epoxy composite [12]. It indicate that elastic modulus value of ALF-glass-UPRs composite higher than other glass hybridization composite for sisal and banana fiber.

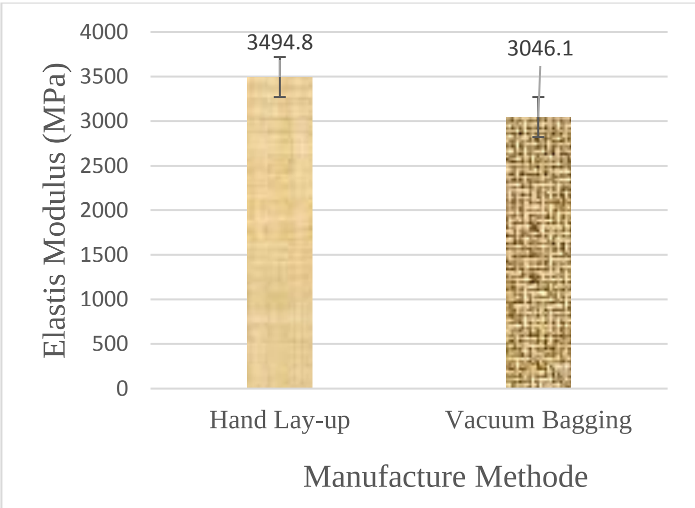

Figure 6. Ratio of manufacturing method to elastic modulus

4. Conclusions

Conclusion of this paper are vacuum bagging strength has 36% higher than hand layup but 13% lower in elastic modulus. It tensile strength and elastic modulus are higher compare to other glass hybridization for sisal and banana composite.

Acknowledgement
The authors would like to thank director of Aeronautics Technology Center (Pustekbang) LAPAN Mr. Gunawan Setyo Prabowo and head of progfas department Mr. Agus Aribowo for providing research support facilities.

References

[1] A. K. Mohanty, M. Misra, and L. T. Drzal, “Sustainable Bio-Composites from Renewable Resources : Opportunities and Challenges in the Green Materials World,” vol. 10, no. April, pp. 19–26, 2002.
[2] V. S. Sreenivasan, D. Ravindran, V. Manikandan, and R. Narayanasamy, “Mechanical properties of randomly oriented short Sansevieria cylindrica fibre / polyester composites,” *Mater. Des.*, vol. 32, no. 4, pp. 2444–2455, 2011.
[3] C. W. Nguong, S. N. B. Lee, and D. Sujan, “A Review on Natural Fibre Reinforced Polymer Composites,” vol. 7, no. 1, pp. 33–40, 2013.
[4] C. Baillie, *Green Composites: Polymer Composites and the Environment*. CRC Press, Taylor & Francis Group, 2005.
[5] S. V Joshi, L. T. Drzal, A. K. Mohanty, and S. Arora, “Are natural fiber composites environmentally superior to glass fiber reinforced composites ?,” *Compos. Part A*, vol. 35, pp. 371–376, 2004.
[6] W. D. Callister, *Materials Science and Engineering An Introduction*, SEVENTHE. John Wiley & Sons, Inc. New York, 2007.
[7] L. Y. Mwaikambo and M. P. Ansell, “Chemical modification of hemp , sisal , jute , and kapok fibers by alkalization Chemical Modification of Hemp , Sisal , Jute , and Kapok Fibers by Alkalization,” *J. Appl. Polym. Sci.*, vol. 84, no. June, pp. 2222–2234, 2002.
[8] R.T. Durai Prabhakaran, Tom L. Andersen, C.M. Markussen, Bo Madsen, Hans Lilholt, "Tensile and Compression Properties of Hybrid Composites – A Comparative Study", The 19th International Conference on Composite Materials, pp. 1029-1035,2013.
[9] Ali I. Al-Mosawi, Mohammad H.Al-Maamori, Zaynab A.Wetwet, "Mechanical Properties of Composite Material Reinforcing by Natural-Synthetic Fibers", Academic Research International, vol. 3, no. 3, November, pp. 108-112, 2012.
[10] Mohd Aidy Faizal, Yeo Kiam Beng & Mohd Noh Dalimin, "Tensile Property of Hand Lay-UpPlain-Weave Woven E-Glass/Polyester Composite: Curing Pressure And Ply Arrangement Effect", Borneo Science, The Journal of Science & Technology, pp: 27-34, ISSN: 2231-9085.
[11] Jarukumjorn, K., & Suppakarn, N., "Effect of Glass Fiber Hybridization on Properties of Sisal Fiber-Polypropylene Composite", Composite: Part B, pp: 623-627, April 2009.
[12] Arthanarieswaran, V.P., Kumaravel, A. and Kathirselvam, "Evaluation of Mechanical Properties of Banana and Sisal Fiber Reinforced Epoxy Composite: Influence of Glass Fiber Hybridization", Materials & Design, pp. 194-202, August 2014.