An effect of humid climate on micro structure and chemical component of natural composite (*Boehmeria nivea-Albizia falcata*) based wind turbine blade

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Abstract. In this work, wind turbine blade NACA 4415 is fabricated from natural composite of Boehmeria nivea and Albizia falcate. The composite fabrication method used is hand lay up method. The aim of the work is to investigate an effect of humid climate of coastal area on micro structure and chemical composition of composite material of the blade. The wind turbine is tested at Pantai Baru, Bantul, Yogyakarta for 5.5 months. The micro structure scanning is performed with Scanning Electron Microscope (SEM) and material component is measured with Energy Dispersive X-ray spectrometer (EDS). The samples are tested before and after the use within 5.5 month at the location. The results show that composite material inexperienced interface degradation and insignificant change of micro structure. From EDS test, it is observed that Na filtration reduces C and increases O in composite material after 5.5 months.

1 Introduction

Wind energy conversion system is very attractive and have been developed worldwide. Composite based wind turbine blade is likely have good performance for low wind speed. Composite material form different natural material have been investigated by various researchers. Sandwich composited made from Albaizia wood and Kenaf fiber is fabricated and investigated by Diharjo et al [1]. The impact properties improves as the thickness of the core increased. Xu, *et al.[2]* studied the life cycle assessment of natural fibers in wood-fiber-reinforced polypropylene composites and introduced the term "material service density" (MSD), defined as the volume of material to meet the specific power requirements. When MSD is used as a functional unit, the wood fiber-reinforced composite is more environmentally friendly than polypropylene. Impact strength of laminating composite increases twice with the use of Ramie fiber [3]. Other natural material used for making composite is waste of starch fiber. This starch fiber waste was used for thermal insulator and sound absorber [4].

Composite material of wind turbine blade which exposed to coastal area will experience extreme weather condition. Regarding environmental factor, temperature and humidity may affect the performance of composite material. Increasing temperature from 50 to 100^0C lowers inter-laminar crack energy of laminar composite 25-30% [5]. Due to high humidity in particular location, water vapor content in air may infiltrate to the composite material. The infiltration may reduce inter matrix bounding [6], hairline crack [7], [8] and also may reduce temperature of glass transition [9].

In this work, wind turbine blade NACA 4415 is fabricated from natural composite of Boehmeria nivea and Albizia falcate. The composite fabrication method used is lay hand up method. The aim of the work is to investigate an effect of humid climate of coastal area on micro structure and chemical composition of composite material of the blade.

2 Material and method

Wind turbine blade NACA 4415 is fabricated from natural composite of Boehmeria nivea and Albizia falcate. The composite fabrication method used is hand lay up method. The wind turbine is tested at *Pantai Baru*, Bantul, Yogyakarta for 5.5 months. The micro structure scanning is performed with Scanning Electron Microscope (SEM) and material component is measured with EDS. The samples are tested before and after the use within 5.5 month at the site. The SEM unit used in this work as shown in Figure 1.

3 Results and discussion

Figure 2 presents photo of cross sectional area of 2 layers composite from the SEM test. The interface between Sengon wood core, resin, and ramie fiber indicated has good bonding due to polar resin used. SEM photo of cross sectional wind turbine after 5.5 months installed at Pantai Baru shown in Figure 3.

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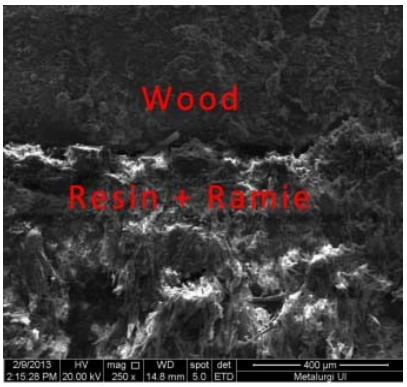
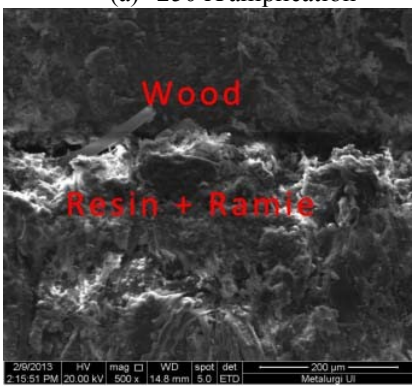
Fig. 1. Scanning Electron Microscope (SEM)



(a) 250 X amplication



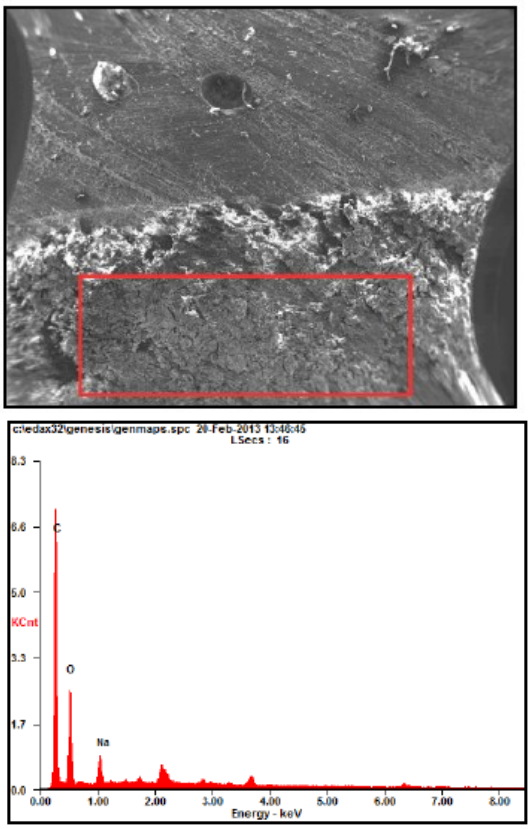
(a) 500 X amplication

Fig 2. SEM photo of composite before used as wind turbine blade

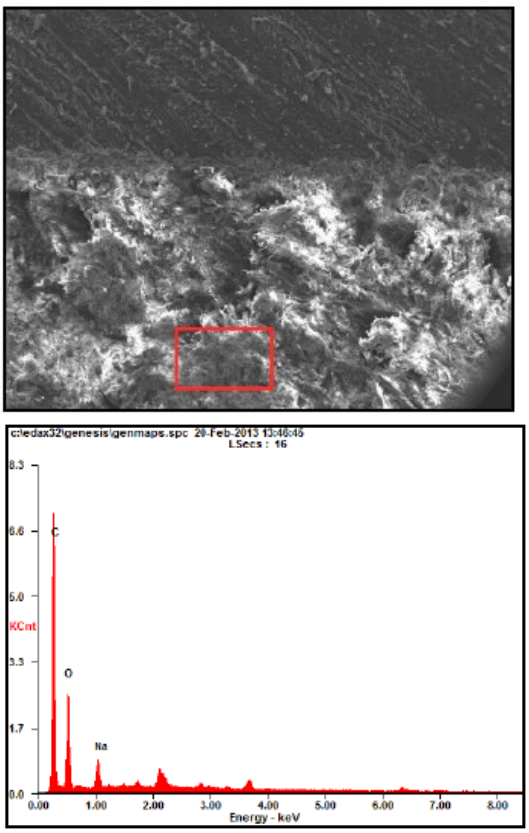
(a) 100 X amplication

(b) 250 X amplication

Fig.3. SEM photo of composite after 5.5 months



(a) SEM & EDS test of resin-ramie part before field test



(b) SEM & EDS test of resin-ramie part after 5.5 months field test

Fig. 4. SEM & EDS test of resin-ramie fiber of the composite before and after field test

After 5.5 months, the micro structure of the composite inexperienced degradation. It indicates that the method of lay hand up is good enough for composite wind blade fabrication.

Figure 4 shows the results of SEM and EDS test of resin and ramie part of composite wind turbine blade. Meanwhile, Table 1 show chemical component of (C, O, Na) of resin-ramie part before and after field test.

Wood is mostly composed by three elements, Carbon, Hydrogen and Oxygen. These elements come from CO_2 in the air and from H_2O from the ground. However, the wood also contains other elements such as Nitrogen, Phospor, Kalium, Calcium, Magnesium, Silikon, Alumina and Natrium. After 5,5 months installation of model, EDS test is conducted. The test result indicates that Carbon decreases by 4.01%, while Oxygen increases by 7.85%. This phenomenon is caused by high humidity at observation site, about 69.98%. This high humidity increases a diffusion of oxygen air into the propeller material.

Table 1. C, O, Na composition of resin-ramie of blade before and after 5.5 months used

Component	Before being used (Wt%)	After 5.5 months (Wt%)
C	59.90	54.95
O	35.77	44.13
Na	4.33	0.91

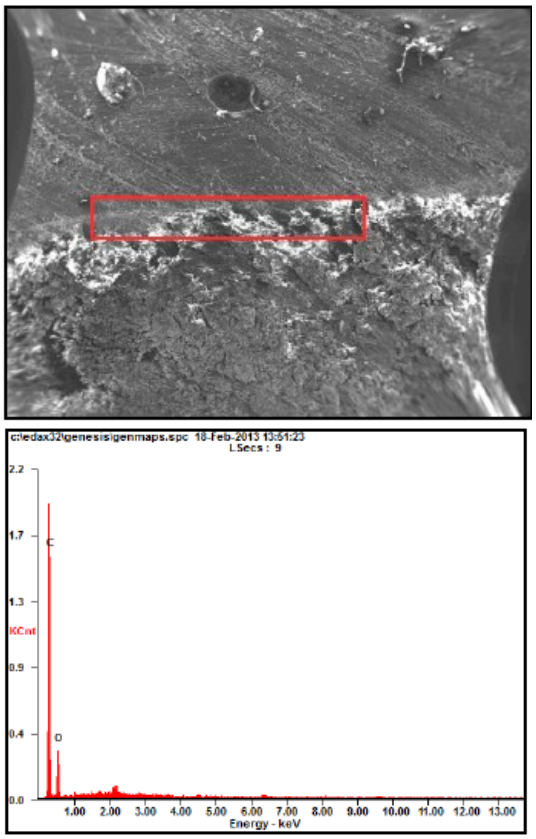
Figure 4 and Table 2 show the results of SEM and EDS test of wood resin-ramie interface of composite wind turbine blade before and after the field test.

Table 2. C, O, Na composition of wood-resin-ramie of blade before and after 5.5 months used

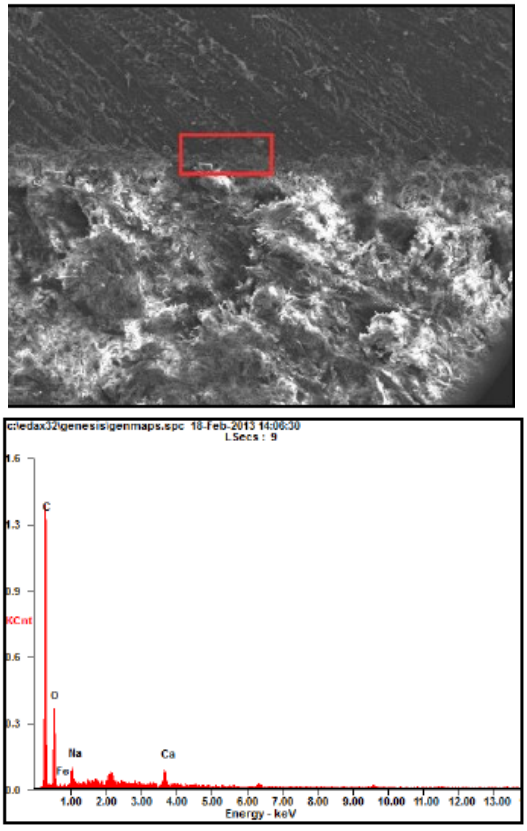
Component	Before being used (Wt%)	After 5.5 months (Wt%)
C	59.69	55.68
O	36.17	44.02
Na	4.14	1.30

In the operational period of time, windmill propellers may be exposed to an extremely temperatures condition. In addition to accelerating the process of water absorption, the temperature also affects the composite resin.

The average weight of all three blades before being installed is 3025 grams. After 5,5 months installation of this composite as wind turbine blades, the weigth is found to be 3.106 grams. So the percentage content of water vapor diffused into the blade material during 5,5 months is 0.44%. This result is not much different from the result obtained by EDS. Percentage of oxygen in composite increases by 0.22% after 5,5 months.



(a) SEM & EDS test of interface between wood and resin-ramie before field test



(b) SEM & EDS test of interface between wood and resin-ramie after 5.5 months field test

Fig. 5. SEM & EDS test of interface between wood and resin-ramie before and after field test

After being tested for 5.5 months at Pantai Baru-Bantul-Yogyakarta, EDS test shows that Carbon (C) content in composite decrease 4.01%, Oxygen (O_2) increases 7.85%. This is due to high humidity of the site during the field test. The humidity at the site during 5.5 months test is about 69.98%. In high moist air, oxygen content in the air infiltrates to composite wind turbine blade.

4 Conclusions

From EDS test, it is observed that Na diffusion reduces C and increases O in composite material after 5.5 months. The results of SEM test show that composite material inexperienced interface degradation and insignificant change of micro structure. It can be concluded that hand lay-up method give good performance of composite blade for encountering the effect of humidity on composite material.

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