FABRICATION, MECHANICAL PROPERTIES, AND INTERFACE STRUCTURE OF RAMIE FIBER COMPOSITE

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ABSTRACT

In present work, ramie fiber based composites are fabricated and tested on its mechanical properties and interface structure. The work aims to investigate effect of volume fraction of ramie fiber (VoF) on mechanical properties (yield and tensile strength, bending stress and strain, and modulus elasticity) of the composites. Besides, bonding and mixing between ramie fiber and resin are also observed under interface structure test. The VoF observed are 25, 35, 45, and 55%. The results indicate that maximum yields strength of 8.03 kgf/mm^2 and tensile strength of 12.29 kgf/mm^2 are obtained in the composite with VoF of 45%. Meanwhile, bending stress of 121.78 MPa and bending stress of 3.25% are observed in the composite with VoF of 55%. Although good bending between ramie and resin are occurred, but non-uniform mixing between the two is observed due to fabrication method used.

Keywords*: composites, fiber, interface, mechanical properties, ramie*.

INTISARI

Dalam penelitian ini, komposit berbasis serat rami dibuat dan diuji pada sifat mekanik dan struktur antarmuka. Penelitian ini bertujuan untuk mengetahui efek fraksi volume serat rami (VoF) pada sifat mekanik (hasil dan kekuatan tarik, tegangan lentur dan regangan, dan modulus elastisitas) dari komposit. Selain itu, ikatan dan pencampuran antara serat rami dan resin juga diamati melalui uji struktur antarmuka. VoF yang diamati adalah 25%, 35%, 45%, dan 55%. Hasil pengujian menunjukkan bahwa kekuatan hasil maksimum 8,03 kgf/mm^2 dan kekuatan tarik 12,29 kgf/mm^2 diperoleh dalam komposit dengan VoF 45%. Sementara itu, tegangan lentur 121,78 MPa dan tegangan lentur 3,25% diamati dalam komposit dengan VoF 55%. Meskipun terjadi lentur yang baik antara rami dan resin, tetapi pencampuran yang tidak seragam antara keduanya juga diamati selama proses pembuatan dengan metode yang digunakan.

Kata-kata kunci: antarmuka, fiber, komposit, peralatan mekanik, rami.

INTRODUCTION

Due to abundant availability in Indonesia, Ramie fiber has a potential for raw material in production of natural ramie composite. Natural composite, one of many attractive composite materials, is very interesting material nowadays. Many works on natural fiber composite habe been reported. Suizu et al. [1] has investigated the use of ramie fiber reinforced materials to produce eco-friendly and strong material. The ramie fiber able to increase composite tensile stress up 2 to 3 time compared with composite without ramie fiber. Other natural fiber of Kenaf was investigated by [2]. Randomly increasing Kenaf fiber content can improve tensile strength and modulus of the composite. Karnani et al. [3] have compared Kenaf-Polyester composite with Kenaf-PP composite. The Kenaf composites - polyester in the study had better tensile properties than the composites of Kenaf-PP. Furthermore [4] have developed a sandwich composite with Albizia as a composite core. Meanwhile, the effect of life cycle of wood fiber reinforced composites (fiber reinforced wood) and polypropylene on the environment have been onserved by Xu, et al. [5]. The test showed that wood fiber-reinforced composite is more

environmentally friendly than polypropylene. In the same volume of material, the composite material has a density lower than polypropylene.

Mechanical properties are important parameter in utilization of composite material. The mechanical properties, such as yield and tensile strength, bending stress and strain, and modulus elasticity have to figure out. Following calculation are used to calculate bending stress and strain, respectively.

$$\pm_f = \frac{3PL}{2bd^2} \quad (1)$$

$$£_f = \frac{6Dd}{L^2} \quad (2)$$

Some more recent works in investigation on mechanical properties of natural fiber composite are conducted by [6], [7], and [8]. Lau et al. [6] investigated natural fiber composites for structural engineering application. Mechanical properties of natural composites from different fiber i.e. Flax, hemp, jute, sisal and coir fibers is performed by Codispoti et al. [7]. Meanwhile, Xie et al. [8] observed mechanical properties of sisal fiber-starch packing composites.

In this work, natural ramie fiber composites are fabricated with different volume fraction of the fiber (VoF), i.e. 25, 35, 45, 55%. The composites are tested to figure out an effect of VoF on mechanical properties (yield and tensile strength, bending stress and strain, and modulus elasticity) of the composites. Besides, bonding and mixing between ramie fiber and resin are also observed under interface structure test.

Material and Method

In this work, natural composite of ramie fiber is fabricated from ramie fiber obtained from Temanggung, Central Java, Indonesia, resin yukalac 157 BQTN, and methyl ethyl keton peroxide (MEKPO) used as a catalyst. The volume fraction of ramie fiber (VoF) is varied during the fabrication, thus results composites four different composite, i.e. composite with VoF of 25%, 35%, 45%, and 55%. Figure 1 shows the materials used in the fabrication of the composite and the fabricated composite.

(a) Ramie fiber

(b) Resin: Yukalac 157 BQTN

(c) Catalyst: MEKPO

(d) The composite

Figure 1. Materials and the fabricated composited

The samples of the composite are then tested to figure out an effect of VoF on mechanical properties (yield and tensile

strength, bending stress and strain, and modulus elasticity) of the composites). The mechanical properties tests are conducted using universal testing machine. Besides, microstructure of the composite is also evaluated under microscope observation. Figure 2 displays photos of the universal testing machine and the microscope.

(a) Universal Testing Machine

(b) Microscope

Figure 2. Testing unit

RESULTS AND DISCUSSION

Yield and Tensile Strength

Figure 3 presents the effect of volume fraction of fiber (VoF) on yield and tensile strength of the composite. The graphs indicate that increasing VoF from 25% to 45% improves yield strength and tensile strength as well. Further increasing in VoF to 55%, the yield and tensile strength decline. Maximum values of yield and tensile strength are obtained for the use of VoF 45%. The values are 8.03 and 12.29 kgf/mm^2, respectively. Yield and tensile characteristic of the ramie play an important role in yields and tensile strength of the composite. Thus, increasing VoF up to 45% able to enhance the yields and tensile strength of the composite. However for VoF of 55% the yields and tensile strength decline. More amount of fiber means that less amount of resin in the composite. This may reduce the yields and tensile strength of the composite.

Bending Stress and Bending Strain

The effect of VoF on bending stress and bending strain is given in Figure 4. In general, the bending stress and strain of the composite step up as VoF increases form 25% to 55%. Higher VoF means more amount of fiber encounter applied bending load, results in higher bending stress and stress properties of the composite. Maximum bending stress and bending stress of 121.78 MPa and 3.25% are observed for VoF of 55%.

Interface Structure

Meanwhile, Figure 5 displays the photo of micro structure of the ramie composite. The photo indicates that the ramie fiber able to bond with the resin well. However, non-uniform mixing between the fiber and resin is observed. This is due to the use of Hand Lay Up method during fabrication. The non-uniform bonding may affect mechanical properties of the composites, thus need more appropriate investigation in future work regarding the effect of interface structure on mechanical properties of the composites.

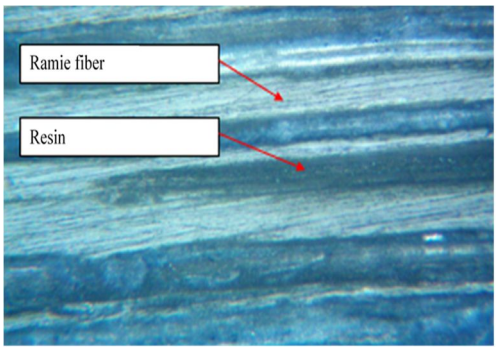

Figure 5. Interface structure of the composite

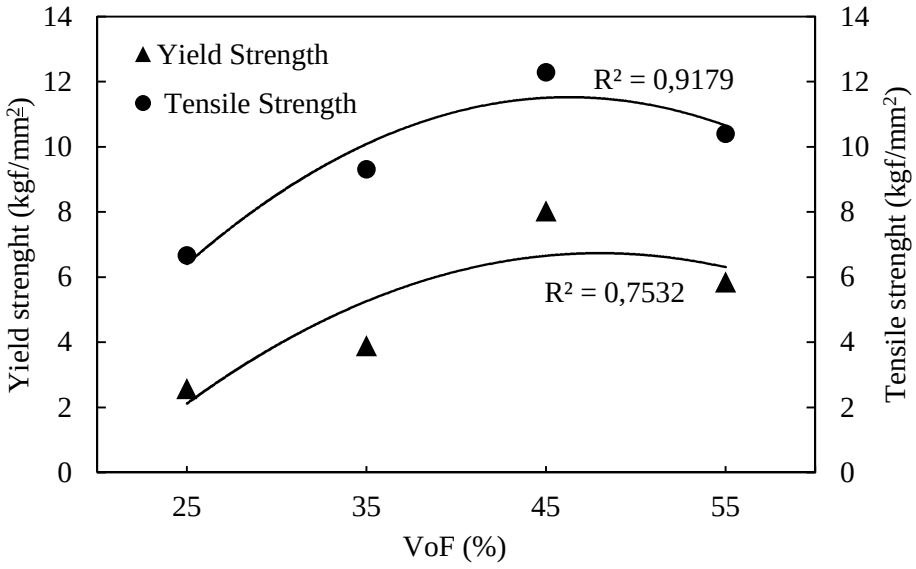

Figure 3. Effect of VoF on yield and tensile strength

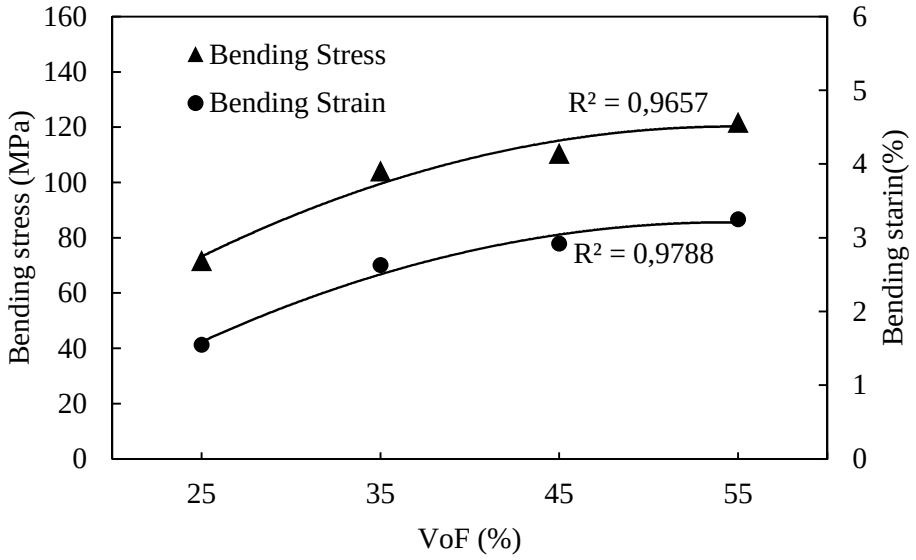

Figure 4. Effect of VoF on bending stress and strain

CONCLUSIONS

The effect of volume fraction of ramie fiber (VoF) of 25, 35, 45, and 55% on mechanical properties and interface structure of the ramie composites are performed. From the work, it can be concluded that maximum yields and tensile strength of the composites are obtained with the use of VoF of 45%. Increasing VoF able to increase bending stress and bending stress of the composite. Although good bending between ramie and resin are observed, but non-uniformed mixing between the two is occurred due to fabrication method used.

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