



Comparison of the mechanical properties of four-layer epoxy composite reinforced with natural jute fibers and symmetrical e-glass synthetic fibers

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ABSTRACT

Research that produces environmentally friendly products continues to be developing. Research related to the natural fiber jute material and epoxy matrix has done. Epoxy composite jute empowered do with the preparation of symmetry with four layers of fiber volume fraction of 27.89% and composite epoxy e-glass Fiber empowered four balance with 28.86% fiber volume fraction. Mechanical testing is done via Drag test to determine the tensile strength and stretch. From the analysis, it's finding that the tensile strength of the symmetry jute fiber reinforced epoxy tensile strength was 48,378 MPa, and the strain was 11,998%. Meanwhile, the tensile strength and pressure in empowered epoxy e-glass fiber symmetry of four layers, each for 95.516 MPa and 7.7032%. Characterization has also been carried out through SEM testing. The results show that e-glass fiber fractures can still be seen as regular and tend to be straight and flat rods compared to symmetrical fiber-reinforced jute composite epoxy composites whose fibers are irregular. So that shows that the strength of the epoxy composite reinforced e-glass fiber is very large compared to the strength of the four-layer jute fiber-reinforced epoxy composite symmetry.

Keywords: jute fiber, matrix, epoxy, composites

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INTRODUCTION

Advances in science and technology have increased the use of composite materials in almost all fields, one of which is metal (Widodo, Basuki 2008). Composite is a material that has formed from a combination of two or more forming materials, where the mechan-

ical properties of each forming material are different (Septiyanto & Abdullah, 2016, Kosim, 2017). The advantages of composite properties can give the mechanical properties of its constituent components, corrosion resistance, economical, and not sensitive to chemicals (Matthew & Rowling, 1994). Com-

posites have superior features such as light-weight, durable, resistant to corrosion, and the raw material available in large quantities (Gupta et al., 2011). Strength of the Composite depends on the fibers used because the fibers should have a modulus of elasticity and tensile strength higher than the matrix (Vlack, 1995)

But behind the superior properties, the composite material is not environmentally friendly and economical (Purkuncoro, 2017). These materials are delicate degraded to produce the waste that will threaten ecosystems if used continuously and massively. The emergence of these problems prompted researchers to the composite nature of technological change that is environmentally friendly. Also, the urge to research natural composites, a growing number of garbage bins, which became one of the significant problems in our country, especially waste that can not described in soil (Syamsul 2019, Masitoh 2019, Sinda 2019). Composite current issues, there are still many who produce waste, which would harm the environment. One of the examples, the use of synthetic fibers in the composite industry, which raises the problem of waste this time. Therefore, pushing forward technological change towards natural composites. Technology use of natural materials, especially the use of natural fibers such as jute, cotton, wool, and others, continue to be developed to replace the synthetic fiber that has been using. However, the strength of different natural fibers, the larger the diameter of the fiber, then its power would be diminished. It is because cavity on large fiber while bonding Among small molecules (Munandar, 2013). and others continue to be developed to replace the synthetic fiber that has been using. However, the strength of different natural fibers, the larger the diameter of the fiber, then its power would be diminished. It is because cavity on large fiber while bonding among small molecules (Munandar, 2013). and others continue to be developed to replace the synthetic fiber that has been using. However, the strength of different natural fibers, the larger the diameter of the fiber, then its power would be diminished. It is because cavity on large fiber while bonding among small molecules (Munandar,

2013).

Natural fibers are categorizing as environmentally friendly fiber. Easily cultivated, they are cheap and abundant availability (Akova, 2013). However, there is a shortage in natural fibers; the mechanical strength is weak (Purwanto, 2016) and is not always evenly distributed, and the low heat resistance and reduced water resistance (Diharjo et al., 2015). One natural reinforcing material is jute. This fiber is obtaining from the bark of plants, and *Corchorus Corchorus Capsularis* planted *olitorius* to be taking Fiber (Dewi et al., 2015). Jute is a biodegradable and environmentally friendly material. This fiber is obtaining from the bark of a tree (called bast fiber).

Composite strength between fiber and matrix is also dependent on the angle of orientation of the fibers in the matrix. If the Composite works with a load parallel to the direction of the fiber, the orientation angle is 0° . Meanwhile, the orientation angle of the fiber is 90° if the load acting on the Composite is perpendicular to the fiber direction. The lower the corner of orientation (toward 0°), the higher the strength of the Composite (Christensen, 1999). The increase in depth of the Composite can occur if the addition of the composition of fibers in the matrix (Okuba, 2004; Yang, 2015). The structure of the Composite can be like, matrices and different fiber diameters, variation in the volume fraction of epoxy polymers with fibers (Veeresh et al., 2008).

This research aims to replace synthetic fibers that are currently generating waste, especially the composite industry. Therefore, this study also aims to provide a solution to the problems of garbage created synthetic fibers. This environmentally friendly research in the form of natural fiber composites has focused on composite studies with reinforcing materials in the form of jute fibers, which are natural and have quite strong characteristics and have the potential to be further developed to produce products of more value. Also, composites research with jute fiber raw materials is expecting to use as a substitute for glass fiber composites that cause environmental waste. While the matrix has used as a binder is the matrix epoxy resin and hardener epoxy matrix.

For comparison with the composite jute done well, research on synthetic fiber composite e-glass as a comparison. E-glass fibers have a cross-section that can be round, triangular, or hexagonal with a variation in diameter between 0.0025 to 0.13 mm (Malau, 2010). Damage can occur in a composite example: fiber disability, buckling, splitting fiber, fiber fallout, the release of the ligament fibers and matrices, and defective matrix (Aboudi, 1991; Herakovitch, 1998)

This study aims to overcome the problem of waste caused by industrial waste composite materials that can not be described by the ground so that a current environmental issue.

RESEARCH METHODS

Materials needed in this research include: a) Jute fiber size of 18 x 18 cm 4 pieces; b) Fiberglass size 18 x 18 cm 3 pieces; c) Epoxy Bishphenol A-epichlorohydrin Resin; d) Epoxy hardener Polyamimoamide; e) distilled water; f) Wax. The study has conducted at the Laboratory of Physics, Clean Technology Research Station, Indonesian Institute of Sciences Bandung.

The material used in this study is Jute fiber and e-glass fiber size 18x18 cm. Epoxy Resin Bishphenol A-epichlorohydrin and Epoxy Hardener Polyamimoamide, waxes, aquades, wipes, cloth, and water. The tools used Molds (size 18 × 18 cm, thickness 2.5 mm) and an aluminum plate size of 31 × 41 × 30 cm, cold tool press, pull testing machine UCT-5T models, SEM JEOL JSM-T330A.

Step-by-step experimental procedures composite manufacture is showing in Figure 1. The first step is the manufacture of composite epoxy resin and hardener mixed in a ratio of 1: 1. Four-ply symmetric fiber inserted into the mold by providing the resin on the fiber. The process further provides composite pressure by using the cold press for 6 hours furthermore, the process of making the test specimen before Pull with ASTM D 3039. After the specimen is print according to the standard, then tested Pull and testing SEM to obtain physical parameters of composite made.

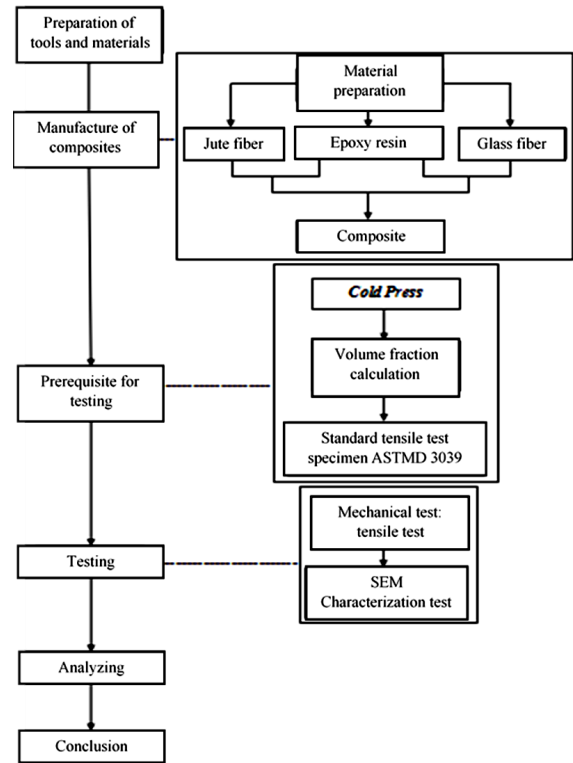


Figure 1. Steps of experiment

RESULTS AND DISCUSSION

The amount of fiber in the Composite is of particular concern to the Composite Fiber. To calculated the volume fraction of fiber (V_f), the parameters must be known the density matrix (ρ_m), the density of fiber (ρ_f), composite mass (m_m) and mass of fiber (m_f).

The fiber volume fraction is determined by the equation, as equation (1)

$$V_f = \frac{m_f / \rho_f}{m_f / \rho_f + m_m / \rho_m} \tag{1}$$

Table 1. Magnitude of composite

Comp.	V_f (%)	σ (MPa)	ρ (g/cm ³)
Jute + Epoxy	27,89	48.378	1.114
E-glass + epoxy	28,86	94.516	1.41

Specification notation: V_f is fiber volume fraction; σ is tensile strength maximum points; ρ is density.

Natural fibers and synthetic jute e-glass arranged in symmetry as shown in Figure 2.

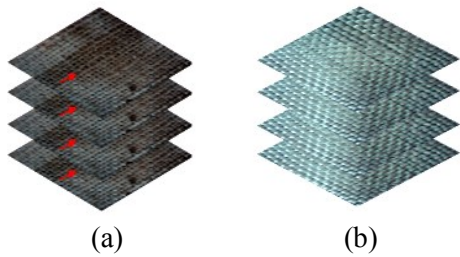


Figure 2. (a) jute four layers of symmetry (b) E-glass fiber are four layers of symmetry.

Pull force testing results (stress) epoxy composite jute and E-glass fiber is shown in Figure 2.

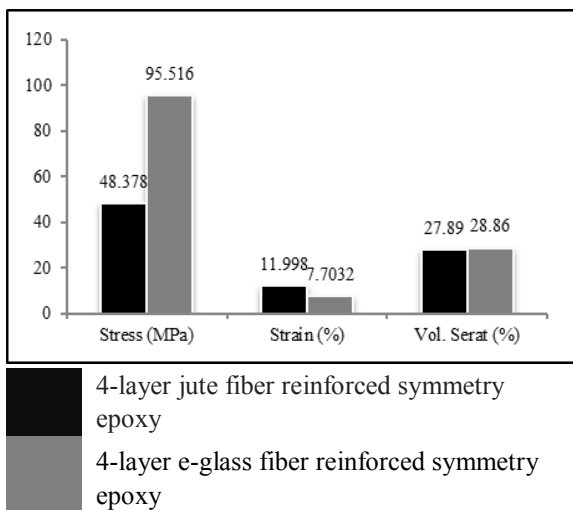


Figure 3. Comparison of tensile strength (stress), added length (strain), and volume fraction of fiber composites

From figure 3 shows that natural fiber composite jute still under synthetic fibers, so that the necessary reinforcement of natural fibers that can challenge the power of e-glass synthetic fibers. The tensile strength of the Composite is affected by the bond between the fiber and the matrix.

The highest stress value on the symmetry 4-layer jute fiber reinforced epoxy composite was 11.998%. Composites having a large fiber volume fraction will tend to be more brittle (E.,

Table 2. The tensile strength (stress), the length (strain), and composite fiber volume fraction Tensile Test

Composite	Maximum Point Stress (MPa)	Breakpoint Strain (% GL)	Volume fractions of fiber (%)
Jute fiber epoxy empowered four-ply symmetry	48.378	11.998	27.89
Empowered epoxy e-glass fibers four ply symmetry	94.516	7.7032	28.86

Purkuncoro, 2017). Therefore synthetic composite e-glass, which has a more substantial fiber volume fraction of jute fiber composites, will have a value of strain (strain) that is smaller.

If we look at the results of SEM of pure epoxy, composite jute, and e-glass will look once differences in the morphology, as shown in Figure 4.

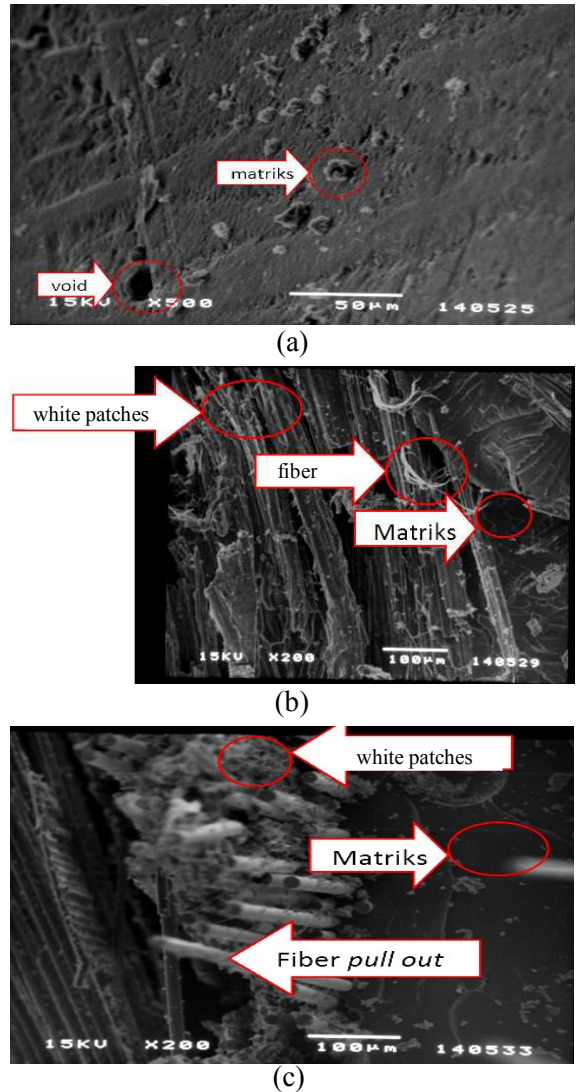


Figure 4. Microstructure cross-section of the fault (a) pure epoxy (b) jute (c) E-glass fiber.

Results fracture SEM microstructure shows a void in the rupture of pure epoxy. This void will affect the strength of the pure epoxy. The presence of voids causes a decline in the power of a material. Also, there are white patches, which is the bond between the matrix. The white pieces are the bond between the fiber and the matrix. More and more white spots on the surface of the fiber, the better the bonding that occurs between the matrix fibers.

The results of the SEM microstructure shows E-glass fibers are still irregular and be straight. It is very different from the jute, which shape is asymmetrical when the fracture has seemed from the SEM microstructure. Also, at fault, this happened fiber composite pull out where the release of the bond between the matrix and fiber composites due to the tearing result of the tensile test. Thus, the majority of e-glass fiber that is experiencing non-bonded fiber pull out again with a matrix. Also, the results of microstructure SEM composite epoxy e-glass fiber empowered no visible voids.

The result is E-glass fiber fault can still be seen regularly and tend always to be straight and flat. Therefore, between the fiber and the matrix, when viewed from the shape, is a noticeable difference. These indicate that the strength of the epoxy composite empowered E-glass fiber is very large compared to the power of pure epoxy and epoxy composite jute allowed.

CONCLUSION

The mechanical strength of the epoxy composite jute empowered not able to counter the power of the epoxy composite empowered glass fiber, which has been using in the industry. Hence, we need another natural fiber amplifier that can counter the influence of the glass fiber.

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