Development of Composite Fiber Materials for Prototype of Car Components

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Abstract
The use of natural fibers as a substitute for glass fiber materials in the development of fiber reinforced composite materials offers a composite material that is environmentally friendly. The application of natural fiber composites has a very wide scope of application, ranging from simple products to products that require knowledge of the mechanical properties of composite constituents and sophisticated manufacturing techniques. This study discusses the development of epoxy-fiber banana composite materials that are applied in the manufacture of car component prototypes.The structural component mold is made with fiberglass material and the manufacturing technique used to print the geometry of structural components is the wet hand lay up technique. The uniaxial test and the three-point flexural test of the abaca-epoxy fiber composite test each provide 953 kg / cm2 tensile strength for 40% fiber volume fraction and 770 kg / cm2 flexural strength for 50% fiber volume fraction. The abaca fiber preform used in the manufacture of simple flat woven components intersects 00-900. The mold of structural components made with fiberglass material and the manufacturing technique used to print the geometry of structural components is the wet hand lay up technique.

Keywords: prototype, composite fiber material
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1. INTRODUCTION

The abundance of natural fibers as a by-product of agro-industrial activities in many tropical countries can cause environmental problems if not handled properly. In general, natural fibers are disposed of as garbage or burned which can pollute the environment. Researchers from various parts of the world at this time have focused their attention on the use of natural fibers and composite materials reinforced with natural fibers which are composite materials that are environmentally friendly. In continental Europe and America, natural fibers cultivated such as jute, flax, hemp, kenaf, are natural materials that are quite intensively used by the automotive industry and building materials.

In Indonesia, natural fibers can be obtained from waste materials from agro-industrial activities, such as coconut fiber (coconut fiber) and pineapple leaf fibers. In addition, natural fibers can also be obtained from the cultivation of certain plants, such as banana stem fibers, ramie fibers, rosella fibers and others. Development and use of natural fiber reinforced composite materials, which in English terminology known as Natural Fiber Reinforced Composites (NFC) can be made at low cost products due to low raw material prices, good acoustic and thermal characteristics, low energy use and environmentally friendly because it is 'biodegradable' and 'sustainable' so that it can be disposed of easily and safely as well as sustainable use.

2. THEORY

2.1. Banana stem fiber

The specific strengths of some types of natural fibers have values that can match the strength of glass fibers, thus enabling the use of natural fiber material as a substitute for glass fiber material which has several environmental disadvantages (Biswas, Srikanth and Nangia, 2001).

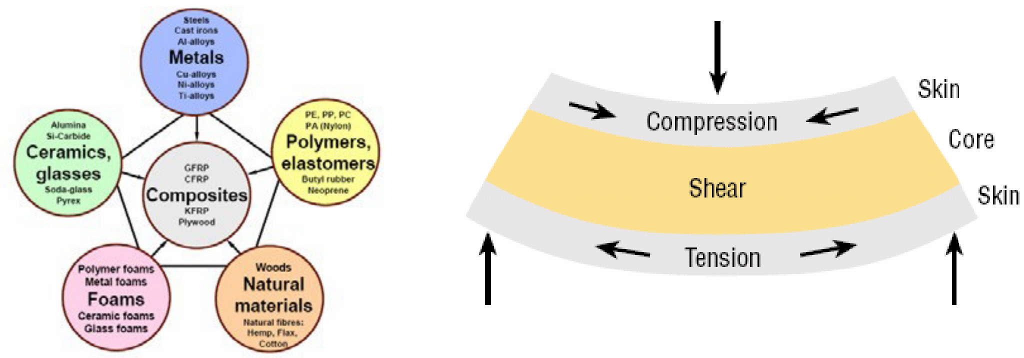
The use of glass fiber in the development of composite materials can result in skin irritation during processing and also in terms of health can cause respiratory problems caused by the ingestion of glass fiber dust. Another driver that intensively spurs the development of natural fiber composites is environmental directives and regulations. For example, the European Union's End-of-Life of Vehicles (ELV) Legislation states that in 2015 all vehicles must use materials that are 95% recyclable - so a total environmentally friendly solution is needed. From this trend it can be estimated that the development of fiber and resin-based environmentally friendly 'green' composite materials can be a solution to these problems (Karus and Kaup, 2002).

In the development of natural composite materials applied to the manufacture of car components which are structural components that can be installed on the roofs of four-wheeled vehicles. Natural fibers used are banana stem fibers which have been formed as woven 00-900 fabrics preform and the matrix material used is epoxy thermoset resin, thus forming a banana-epoxy stem fiber composite material.

The geometry of the components is designed by taking into account the shape of the aerodynamics of the structure, so that it can reduce the drag (drag) of the air fluid when used. Component molds are made using fiberglass reinforced polyester composite material. The manufacturing technique used in this case is a relatively simple wet hand lay up technique and the curing process is carried out at room temperature and standard atmosphere.

2.2. Composite Material Concept

Basically composite material is a homogeneous material that is made by combining synthetically between two or more types of material to obtain certain desired characteristics and properties (Askeland, 1984). For example, if you want a composite material that has a light but strong characteristic for bending flexible loads, this can be developed with laminated composite materials that use core material to increase the rigidity of the laminate with the thick influence of core material which has a low density. The effect of increasing the thickness of the material due to the installation of core material between the two composite material laminates will increase the flexural rigidity of the composite panel compared to the third power of the thick composite laminate with the cores made, but with very little weight addition. Various possibilities of composite materials made by combining various types of constituent materials can be seen in Figure 1.



a. composite materials and its constituents b. bending load in composite materials

Figure 2.1. Composite Material Concept

2.3. Composite Banana Fiber - Epoxy

Banana fiber is a natural fiber that is cultivated and used for various applications in Indonesia. In the study here, Abaca (Musa textiles) fibers are used as reinforcing fibers in composite materials using epoxy resin matrix which is a thermoset polymer material. Mechanical properties, in this case the tensile strength, of abaca fibers used in this study can be seen in table 1.

Table 1. Mechanical properties of Abaca fiber (Musa textiles)

Abaca *(Musa textiles)*		
Weight per 50 cm	**Tensile Strength (kg / g.m)**	**Extension (%)**
0,04	150,42	2,58

While the mechanical characteristics of the epoxy resin matrix material used in this study can be seen in Figure 2.2

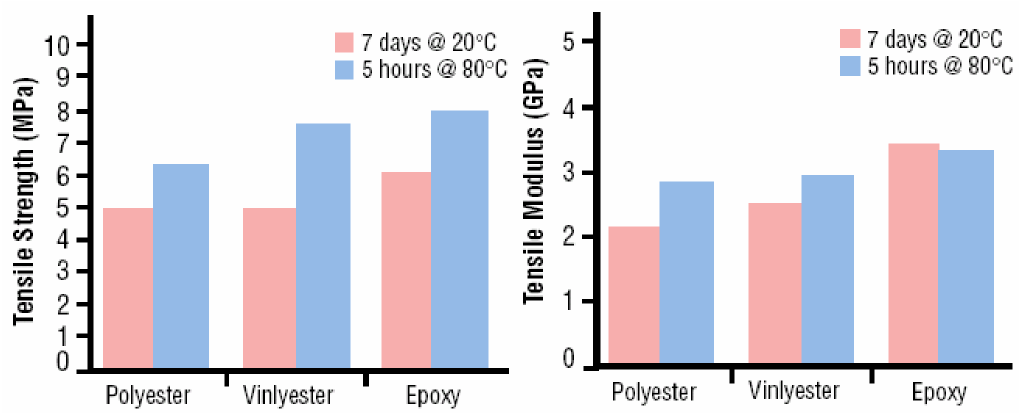


Figure 2.2. Mechanical Properties of Thermoset Resin - Epoxy - Vinlyester – Polyester

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3. METHODS

3.1. Wet Hand Lay-up Manufacturing

The wet hand lay-up technique in making composite materials is a relatively simple manufacturing technique both in terms of the equipment used and also the process. The wet hand lay-up manufacturing process can be seen in Figure 3.1.

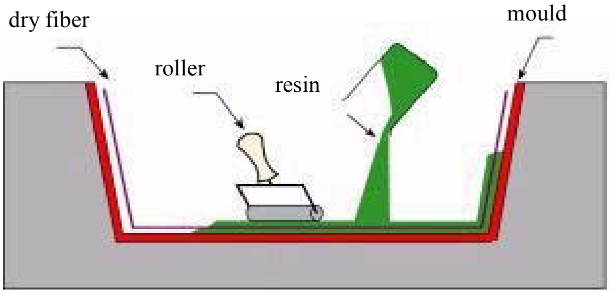

Figure 3.1. Composite Manufacturing Technique - Wet Hand Lay Up

As can be seen in Figure 4, the resin / matrix material is loaded into the fiber preform using a roller (impregnator) manually. After the resin material absorbs the fiber preform evenly, then the laminated composite material layer is allowed to dry (curing) in standard atmospheric conditions. In this study, the wet hand lay up manufacturing technique is used both for mold making and automotive component structure.

3.2. Manufacturing of Component

Making a component prototype of the automotive rooftop cargo box includes geometry design that has aerodynamic geometry, master model making, mold making, manufacture of abaca fiber preforms in the form of abaca fiber woven sheets and manufacturing of car component structures.The main dimensions of the prototype structure of the automotive rooftop cargo box have a length of 128.1 cm, a width of 67.9 cm and a height of 31.6 cm. The geometry design of the structure of the car can be seen in Figure 3.2.

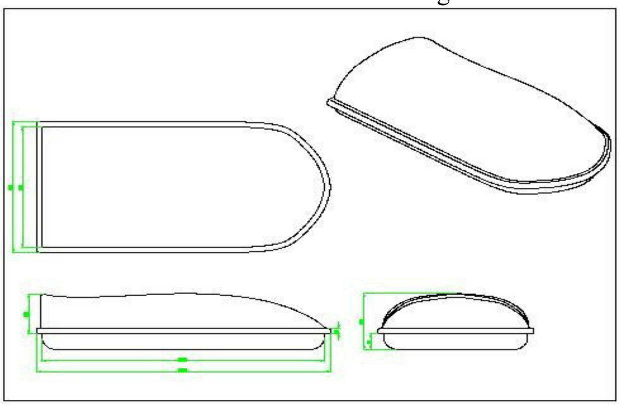

Figure 3.2. Geometry Design

3.3. Manufacture of master models and molds components

To get the geometry of the upper and lower shell structure of the rooftop cargo box, the master model of the previously designed component geometry is first made. The parent component model is made of wood. After the master model was obtained, then the next printed roof cargo box was made using glass fiber and polyester resin to obtain polyester-fiberglass prints. The process of making molds of this component can be seen in Figure 4.1.

a. model b. lay up prosess c. Polyester-Polyester Molds

Figure 3.3. Component Molding Process with Polyester Glass Fiber Material

3.4. Making Components with Abaca-Epoxy Fiber Composites

To facilitate the manufacture of abaca-epoxy natural fiber composites, it is first made a fiber preform in the form

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of woven abaca fabrics. The abaca fiber webbing architecture is made with a flat woven pattern interlacing 0-90^0 as can be seen in Figure 3.4 The integrity of the woven is obtained by mechanical interlocking between the abaca yarn fibers. The ability of woven sheets to follow the shape of a surface, surface fineness and woven stability in this case is largely determined by woven or knitted patterns carried out. The woven pattern also greatly affects the weight of the broad unity and porosity of the woven abaca fibers. The nature of porosity of woven sheets is very important in the development of natural fiber composites. With a high porosity value, it is expected that the resin can enter into the pores of the natural fiber sheet well, so that there is good binding between the natural and resin / matrix material. see picture 3.4 below:

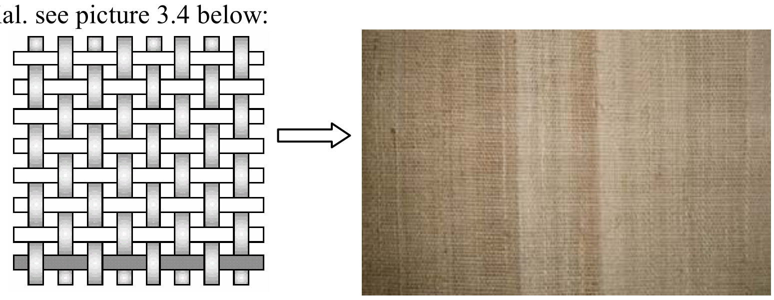

Figure 3.4. Abaca Fiber Woven Pattern as a Strengthening Preform Fiber

The main stages carried out in making the component structure of the automotive rooftop cargo box consist of the following stages:

- Geometric design of the structure of a rooftop cargo box taking into account the aerodynamic form
- Fabrication of main models of rooftop cargo boxes using wood
- Fabrication of printed rooftop cargo box made from polyester-fiber glass material into the surface geometry of the component master model
- Work on smoothing surfaces from fiberglass prints.
- Provision of mold releasing agents on fiberglass surface.
- The process of working wet hand lay ups and installing sheets of abaca fiber on the resin surface in the mold (mold)
- Curing process of abaca-epoxy natural fiber composite laminates at room temperature.
- Opening of structural components of rooftop cargo boxes from fiberglass prints.
- Installation of prototype equipment for rooftop cargo boxes (such as: rubber seal, hinges and locks)

The prototype of car component produced using wet hand lay up manufacturing techniques can be seen in Figure 3.4.

Figure 3.4 The prototype of car component

4. RESULTS AND ANALYSIS

The wet hand lay up technique used in this study to make car component prototypes has a number of advantages, namely easy to do and relatively does not require expensive equipment and can be done at room temperature. In the process of carrying out the wet hand lay up carried out, it is experienced that parts on the surface of the component have excess resin, also known as resin rich area. The part that is rich in resin (resin rich area) will make the composite properties not homogeneous, thereby reducing the quality of the composite material produced. Also from work experience, it is relatively very difficult to get results that are free from voids (voids) on the component parts that are being layered with resin. This is very much determined by the skills of the workers involved. In addition, styrene emissions from resins can endanger workers' respiration.

The mechanical properties of the abaca-epoxy fiber composite material obtained are very dependent on the weight fraction or volume fraction of natural fibers combined with epoxy resin matrix material. In this study, the effect of the volume fraction on the uniaxial and flexural tensile strength of the abaca-epoxy fiber composite material was evaluated by conducting uniaxial tensile testing and three-point bending test of tensile and flexural specimens made with ASTM D 3039M-95A standard (ASTM, 2003) The results of tensile test and three-point flexural test for various values of volume fraction of abaca fiber with epoxy resin respectively can be seen in Figure 4.1 below:

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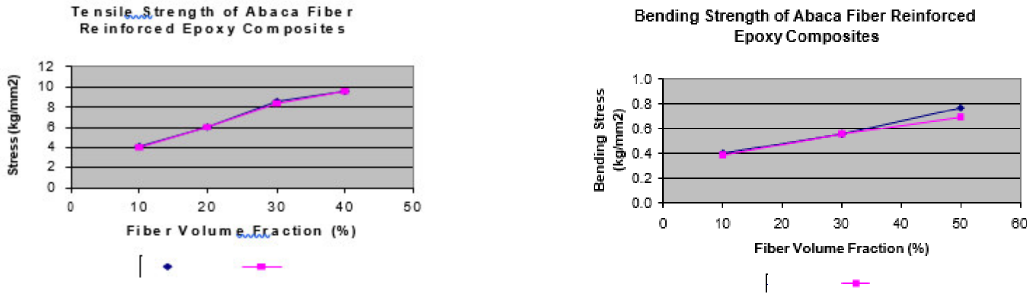

a. tensile strength vs fiber volume fraction b. bending strength fiber volume fraction

Figure 4.1 Effect of Fiber Volume Fraction on Strong Mechanical Abaca-Epoxy Composites

As can be seen in Figure 4.1. the mechanical strength of the abaca-epoxy composite material increases with the increase in fiber volume fraction. Peak stress is the maximum voltage a material can attain during testing, while a breakdown / breakdown or break stress is the voltage at the time the test object fails in carrying out the test load which increases in intensity gradually. In the uniaxial tensile test of abaca-epoxy composites obtained a maximum tensile strength of 953 kg / cm2 for fraction of abaca fiber volume of 40% and maximum flexural strength of 770 kg / cm2 for volume fraction of abaca fibers by 50% It should be noted that each voltage value in Figure 4.1 above is the average value obtained from the testing of each of the 7 test pieces.

CONCLUSION

From the trial of the application of the acaba-epoxy fiber composite material to the manufacture of rooftop carbo box structural components, the following conclusions can be drawn:

- Uniaxial tensile test and three-point bending test performed on abaca-epoxy natural fiber composite test showed that the tensile strength and flexural strength of the abaca-epoxy composite material were strongly influenced by the volume fraction of the fiber used. In the mechanical testing carried out in this study obtained the tensile strength of abaca-epoxy composite test material of 953 kg / cm2 for fiber volume fraction of 40%, while for flexural strength of 770 kg / cm2 for fiber volume fraction of 50%.
- The potential for the application of natural fiber composites is very wide and varied, ranging from applied simple non-engineering to applied engineering that requires the design and calculation of structural strength. Thus, natural fibers can be potential candidates to replace expensive glass fibers to apply fiber-reinforced composites to components that do not carry too large a load. Besides that, natural fiber composite materials offer a material that is more environmentally friendly.
- The trial of the application of abaca-epoxy natural fiber composites to the manufacture of prototypes of automotive roof cargo box components using wet hand lay up manufacturing techniques has resulted in a relatively reliable shell prototype structure. The potential for non-homogeneity in materials using wet hand lay up and curing manufacturing techniques at room temperature is mainly due to the skills of laminate workers, namely the presence of non-homogeneity in the component lay-up resin (resin rich area) and voids that are formed because the resin is not included in the part that is difficult to achieve with the manual lay up process. Therefore, it is necessary to increase the use of better manufacturing techniques, such as the vacuum assisted resin infusion technique which promises the process of impregnating the resin into a more homogeneous fiber preform.

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