# The Influence of Fiber Composition on Tensile Properties and Machinability of Polyester/Biduri fruit fiber composites

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## ABSTRACT

This research was carried out to investigate the tensile properties and machinability of polyester composite materials reinforced with biduri fruit fibers. Composite materials are supplied in a variety of fiber compositions made by hand lay-up. Tensile testing was used to obtain tensile properties using an Instron tensile testing machine, while to obtain machinability, the machining process was carried out using an Agma CNC milling machine with a drill and end-mill process, the machining results were observed on the cut surface to analyze the machining quality. From the tensile test results, tensile strength and modulus of elasticity can be obtained. The tensile properties obtained from composite materials do not show consistent results, this is due to the influence of the composite manufacturing process and the nature of the fibers which absorb very high water vapor. Observation of the machining traces shows that the machining quality improves when the fiber composition increases.

Key words: composite, fiber, tensile properties, machinability

## INTRODUCTION

Biduri fruit fiber (Calotropis gigantea) which is obtained from the inside of the fruit is old, the shape of this fiber resembles cotton which is very soft, very smooth, strong and in the hollow fiber like a smooth pipe it has a white color and a very attractive appearance. This fiber is a natural fiber which can be used as an alternative material for reinforcing composite materials (natural fiber reinforced composites) and can also be used for other textile industry materials [1], this fiber is a cellulose material. Biduri fruit fiber can also be used as an alternative as a substitute for synthetic fibers such as glass fiber, carbon fiber and kevlar. Composite materials that can be developed using this fiber are thermoset or thermoplastic matrix composites. Composite materials reinforced with natural fibers with a polymer matrix are currently being used in the automotive industry [2,3], construction [4] and for household use [5]. Composite materials reinforced with natural fibers have several advantages and superiority that cannot be fulfilled by composite materials reinforced with synthetic fibers, namely low cost, low fiber density, high fracture toughness [6], non-toxic, eco-friendly [7], and renewable source of natural fiber[8,9], while the specific strength is comparable to that of artificial fibers.

For the matrix material which functions as a binding material in composites, it can be chosen from thermoset or thermoplastic materials, one of the thermoset materials is polyester resin which is very possible to make composites of small structures or large structures and can be produced at low cost and polyester generally shows high durability. good for the environment [10].

In the machining process carried out with a drill on polyester composite specimens reinforced with biduri fruit fibers carried out by [11], the results show that with the increase in fiber composition there is a reduction in cracking and delamination in the composite material when compared to plastic materials without fiber reinforcement or 0% fiber weight.

The process of making polyester matrix composite materials and biduri fruit fiber reinforcement can be done using the hand lay-up method.

The purpose of writing this article is to discuss the influence of fiber composition on the tensile properties and machinability of polyester composite materials reinforced with biduri fruit fiber.

## EXPERIMENTAL METHOD

Preparation of composite materials using biduri fruit fiber as reinforcement and polyester resin which functions as a matrix. The biduri fruit fibers can be seen in Figure 1, the biduri fruit fibers inside have holes and have thin walls as shown in Figure 2, a microphotograph observed using a scanning electron microscope (SEM). The fiber taken from biduri fruit still contains high levels of water vapor, it is dried in sunlight, while the polyester resin is in liquid form.

The fiber weight composition and weight content of polyester resin in the composite manufacturing process are % fiber/% resin, namely 0.5/99.5, 1/99, 1.5/98.5 and 2/98. Making composite materials is done using the hand lay-up method, this method is a method that is very easy to use in the process of making composite materials. The lay up process of the composite material is carried out in a flat glass mold. and for processing test specimens are capable of being machined using machining processes carried out by drilling and milling using an end-mill process. The influence of fiber content on machining quality was observed on the machined surface.

Figure 1. Biduri fruit fiber

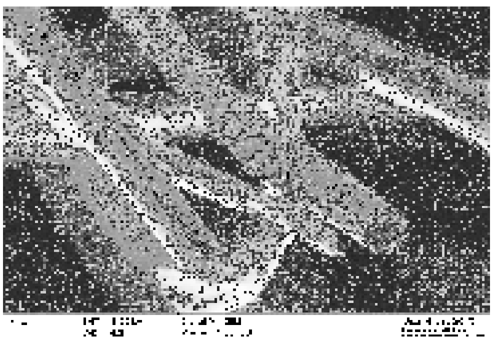

Figure 2. Photomicrograph of biduri fruit fiber using a scanning electron microscope

The Composite materials that have been made to be used as tensile test specimens. Tensile tests were carried out to determine the tensile properties of the polyester reinforced biduri fruit fiber composite . Tensile testing is carried out slowly adding a tensile load at the end of the rod so that it results in an increase in the length of the material in proportion to the tensile force obtained by the material [6].The tensile test used refers to the ASTM D 638-I standard as in Figure 3.

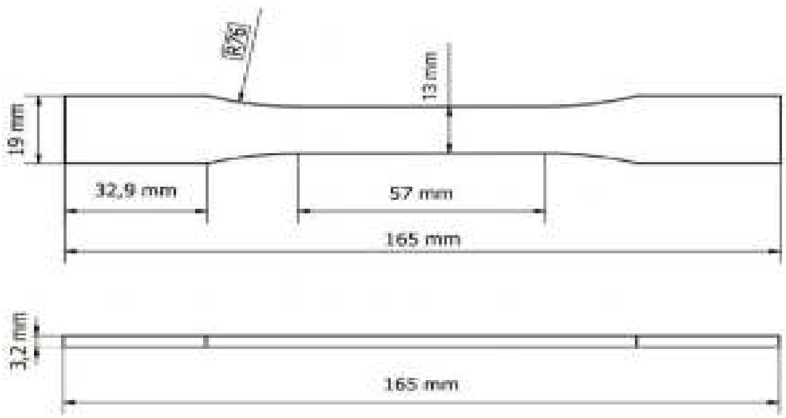


Figure 3. ASTM D-638-I Tensile Test Specimen

To determine the machinability of polyester composite materials reinforced with biduri fruit fiber, the machining process was carried out by drilling and milling using the end-mill process. The influence of fiber content on machining quality was observed on the surface of the machining trace. the drilling process for the specimen is perpendicular to the fibers using a CNC milling machine

## RESULTS AND DISCUSSION

Based on the tensile tests that have been carried out on polyester specimens and polyester composites reinforced with biduri fiber, the data obtained have been plotted in graphs such as Figure 4 which shows the relationship between tensile load and fiber composition. The curves show that the load required to pull the polyester is higher than the load required for biduri fiber polyester composites in all compositions, and the curves do not show consistent results. Figure 5 shows the curve of the relationsip between maximum stress and fiber composition, as well as the tensile load curve. The tensile strength of polyester shows higher than that of biduri fiber polyester composite, the thermal strength of the composite shows a decrease with increasing fiber composition. A decreasing trend also occurred in the elastic modulus as in Figure 6, which shows the relationship between the elastic modulus and fiber composition.

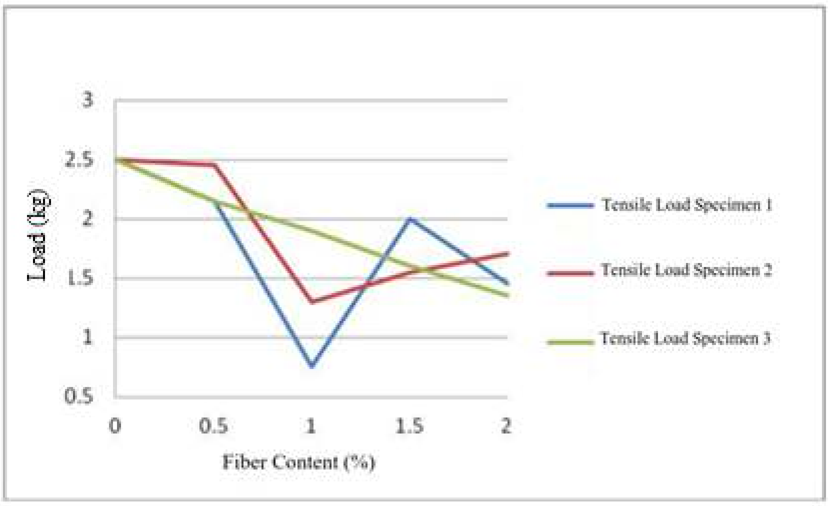


Figure 4. The relation of tensile load with fiber composition

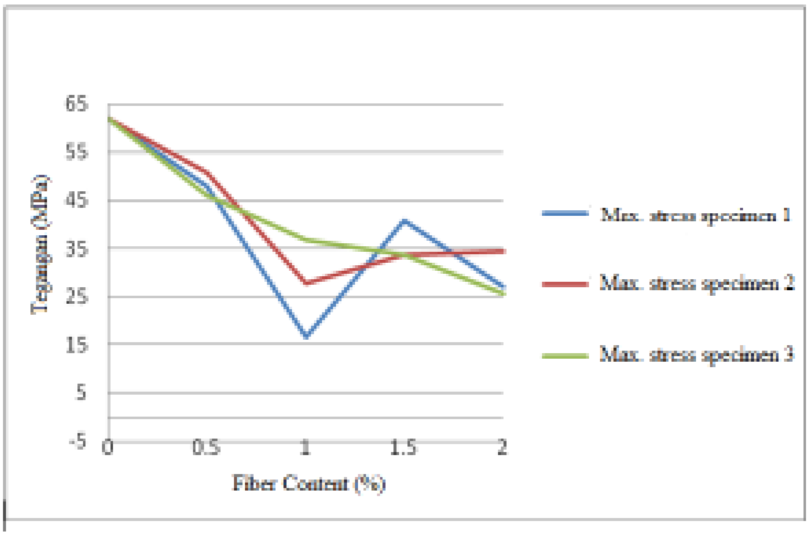


Figure 5. The relation of maximum stress with fiber composition

The decrease in strength and modulus of elasticity of composite materials is thought to occur due to the process of making composites and drying fibers which cannot be tightly controlled. In the manufacturing process using the hand lay-up method, the quality of the composite cannot be maintained consistently for all polyester and fiber compositions. Besides that, the fiber drying process also cannot maintain the same moisture content in all composites, because biduri fiber absorbs water vapor very easily. This can result in unequal composite qualities so that the strength and modulus of elasticity are still heavily influenced by the composite manufacturing process and the properties of the biduri fiber.

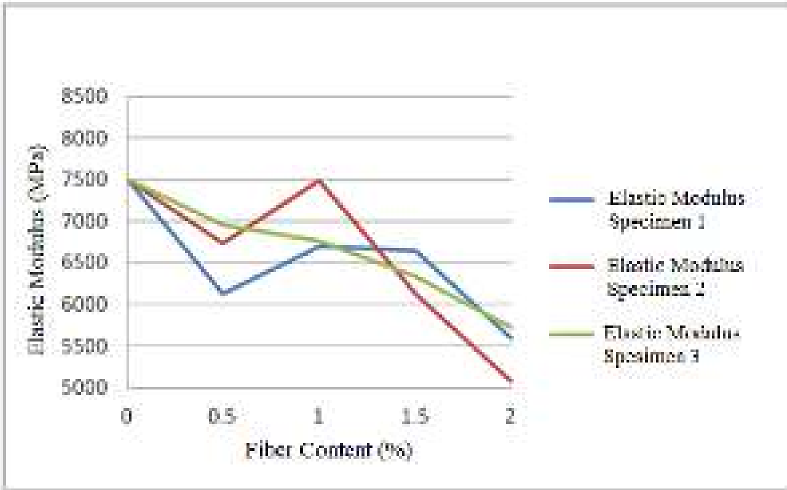


Figure 6. The relation of elastic modulus and fiber composition

The results of the machining process for polyester composite materials reinforced with biduri fiber are used to analyze the machinability properties as in Figure 7. The machining process for composite materials is carried out by varying the cutting speed and biduri fiber composition. The machining direction is perpendicular to the reinforcing fibers. The first composite material composition contains 1% biduri fiber, the second composition contains 2% biduri fiber and the third composite material composition contains 3% biduri fiber.

Observations were made on the machining traces and by studying the cutting results as can be seen in Figure 6, the process of machining composite materials using an end-mill. The end-mill tool starts cutting from the right side with the tool in mark and finishes cutting on the left side with the tool out mark. The columns in the figure show the cutting parameters and fiber composition as well as the polyester composition in the composite material.

Damage that occurs to the composite due to the machining process occurs when the tool enters the composite and when the tool leaves the composite. Damage when the tool enters the composite is caused by the impact load from the movement of the cutting tool hitting the composite which causes the composite to break or crack at the entry side. Damage to the tool exit side of the composite is caused by a decrease in the residual strength of the composite material which is no longer able to withstand the load from the tool movement which can cause fracture or cracking of the composite material.

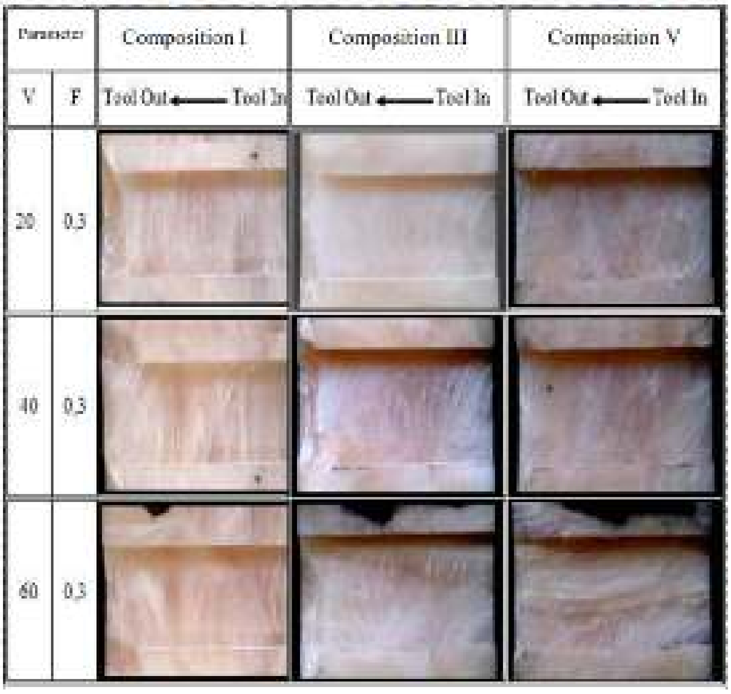


Figure 7. Surface results from machining carried out with an end-mill at various cutting speeds and fiber composition. V, cutting speed and F, Feeding

Fiber composition shows an influence on cutting results, the higher the fiber composition, the better the cutting results, because the fiber is able to reduce the load from the cutting tool and resist or prevent crack propagation in the matrix.

## CONCLUSION

The above discussion on the tensile properties and machinability of hand lay-up polyester composites reinforced with biduri fruit fiber highlights the difficulty in achieving uniform material quality. Based on the tensile test results of composite materials, the tensile strength of composites has not shown consistent results. In the machining process, fiber composition influences machining quality. The higher the fiber composition, the better the cutting results. Greater damage occurs on the chisel exit side of the composite due to the decrease in the strength of the composite material.

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