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***Tarumanagara International Conference on the Applications of Technology and Engineering 2019***

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Paper Title: **Socket Prosthesis Manufacturing Process Made From Bamboo Fiber Composite Materials**

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| Full Paper Submission Deadline | September,14 2019 |
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# Preface

# 2nd Tarumanagara International Conference on the Applications of Technology and Engineering 2019

## Preface

On behalf of the organizing committee of 2nd Tarumanagara International Conference on the Applications of Technology and Engineering (TICATE) 2019, I would like to welcome all delegates to Jakarta, Indonesia with great pleasure. Being held from November 21 to 22, 2019 at Campus I- Jl. Letjen. S. Parman No. 1, Jakarta, the international conference is organized by Universitas Tarumanagara (UNTAR) and technically sponsored by IOP Publisher.

TICATE 2019 has attracted many academicians, scientists, engineers, postgraduates and other professionals from many countries. This conference accepted 215 papers from 7 different countries, those are Australia, Taiwan, India, Malaysia, Japan, Peru and Indonesia. The aim of the conference is to promote exchange of ideas among engineers, researchers, and scientists active in the related areas of technology and engineering.

Our special thank goes to our Rector, Prof. Dr. Agustinus Purna Irawan, who has initiate this international conference, to our Plenary Speakers, Dr.-Ing. Joewono Prasetijo from Universiti Tun Hussein Onn, Malaysia, Prof. Dr. Tjokorda Gde Tirta Nindhia from Udayana University, Indonesia, Prof. Dr. Srikantappa A.S. from Cauvery Institute of Technology, India, and Prof. Dr. Mohd. Zulkifli Abdullah from Universiti Sains Malaysia, Malaysia, and Prof. Yasuyuku Nemoto, Ph.D. from Ashikaga University, Japan.

Our special thank also goes to Tarzan Photo and PT. Astaguna Wisesa as our patrons. Also to all individuals and organizations such as the members of international editorial board, the conference organizers, the reviewers and the authors, for their contribution in making TICATE 2019 as a successful international conference and a memorable gathering event. I am also grateful for the support of publication service of IOP Publisher. We hope that the conference could present you wonderful memories to bring home in addition to new insights and friendship congregated during the event.

We truly value your participation and support for the conference. We hope that you will enjoy TICATE 2019 and culture and tradition in Jakarta.

Dr. Hugeng, S.T., M.T. (SMIEEE)

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# Socket prosthesis manufacturing process made from bamboo fiber composite materials

IOP Conf. Series: Materials Science and Engineering **852** (2020) 012042 doi:10.1088/1757-899X/852/1/012042

# Socket prosthesis manufacturing process made from bamboo fiber composite materials

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**Abstract.** This research aims to develop the manufacturing process of making socket prosthesis with bamboo fiber composite material and epoxy matrix. Bamboo fiber was chosen because it is strong, environmentally friendly, and recyclable. The focus of research is to arrange the manufacturing process of making sockets, starting from material preparation to socket testing. The method used in this study is a customized method and prototype socket manufacture in accordance with the dimensions obtained from the patient. Based on the results of the research that has been carried out, stages of the manufacturing process, results of compressive strength testing, and morphological analysis of socket products are obtained. These results will be a reference in future research. Keywords: socket prosthesis, manufacturing, bamboo, composite material.

## 1. Introduction

Indonesia has abundant natural fiber potentials such as bamboo fibers with various types. Bamboo has good strength, is environmentally friendly, can be recycled and has the potential to be further developed into high quality products. One manufacturing product that can be developed using bamboo fiber composites is a socket prosthesis product [1-7].

This research aims to develop the manufacturing process of socket prosthesis with bamboo fiber reinforced composite material with epoxy matrix. Prosthesis is a product that is needed by patients who experience amputation of the lower limbs due to trauma and degenerative diseases. The socket prosthesis manufacturing process is developed using a customized method according to the dimensions of the patient's stump. The manufacturing process will determine the success in making socket prosthesis products according to the needs and comfort of the patient. Manufacturing process procedures must be designed in such a way that no processes are missed, so that the quality of the product is in good condition [8-11]. Based on this research, a complete procedure for the manufacturing of socket prosthesis from a bamboo fiber composite material will be obtained. The resulting process procedure is the result of a trial making prototype of socket prosthesis which can then be used as a reference in the manufacturing process of socket prosthesis using bamboo fiber composite materials.

## 2. Method

This research is aimed at developing the manufacturing process of socket prosthesis from epoxy bamboo fiber composite materials. The selected bamboo is a type of bamboo rope that

is old and dry, which has good tensile strength, is quite elastic, has good flexural and impact strength. Continuous bamboo fiber is prepared with dimensions of length 50 cm, thickness 0.3 ± 0.05 mm and width 3 mm ± 0.5 mm. The bamboo fiber is then soaked in 90% alcohol solution for 10 minutes then dried until it is completely dry, to remove the waxy layer and increase the strength and elasticity of the fiber. After going through the soaking process, bamboo fiber is then woven into sheets. The fiber is woven with transverse and longitudinal fiber orientation, with fiber orientation $0^0/90^0$. Bamboo matting is not made tightly with the aim that the epoxy resin in lubricating all parts of the met during the resin lamination process using epoxy. The matrix used is the Epoxy Resin Bakelite@EPR 174 matrix with Epoxy Hardener V-140 with a mixture ratio between epoxy and hardener is 1:1.

In general, the procedure for socket prosthesis manufacturing processes is as follows: measurement of patient anthropometric data; negative mold making; positive mold making; socket making; initial assembly and fitting process; the process of repair and final completion, and; the process of analyzing the path pattern of the prosthesis user. Tests conducted to determine the strength of socket prosthesis products with epoxy bamboo fiber composite materials are compressive failure testing according to ISO 10328 and morphological testing with the help of Scanning Electron Microscope (SEM) [6], [12].

## 3. Result and discussion

The results of the manufacturing process of lower limb prosthesis socket manufacturing process has resulted in a good manufacturing process to produce socket products. The manufacturing process begins by preparing fiber raw material in the form of woven and matrix in the form of epoxy resin. The next step is measuring the patient's stump dimension and making negative molds. Negative mold is the basis for making positive molds using gypsum. After the positive mold is finished and finished, the positive mold is ready to be used in the socket prosthesis manufacturing process [13-16].

**Figure 1.** Manufacturing of negative mold of socket product

In the making of the socket made from epoxy rattan fiber, the composition of the material from the inside to the outside part is as follows:

a. The inside is a positive mold made from gypsum compound or cement whose surface has been finished in accordance with the shape and contour of the patient's stump.
b. On the surface of the positive mold, a special layer of prosthesis is given with a thickness (0.5-1.5) mm. The plastic layer serves as a refiner for the inner surface of the socket and as a protector for the lamination or casting process, so that the epoxy resin does not leak

into the positive mold. The protective plastic also functions as a media for the vacuuming process during the lamination process, so that no voids or air bubbles are trapped inside the socket. Voids impair and reduce socket strength.

c. On top of the inner protective plastic, given an inner reinforcing layer using a special prosthesis stockinette. The thickness of the stockinette used is (0.5-1) mm with a total of 3 layers. This stockinette layer is very much needed as a reinforcement in the inner socket, to smooth the surface and to arrange the fibers to keep them neatly arranged.
d. After the stockinette layer as the inner reinforcing layer, a webbing of bamboo fiber is convoluted with a thickness of one layer above the reinforcing stockinette layer. The selected bamboo fiber is bamboo rope fiber, which is a quite mature, dry, and continuous fiber. The woven bamboo fiber wrap is neatly made and arranged so that it follows the surface of the positive mold. The excess parts are then cut and tidied up again.
e. On top of woven bamboo fiber layer, it is given a reinforcing layer in the form of a layer of stockinette with a thickness (0.5-1) mm, with a total of 4 layers. The purpose of this reinforcing stockinette layer is to obtain a strong, smooth, and neat outer surface of the socket prosthesis. This outer stockinette layer also functions to arrange in such a way that the layer of woven bamboo fiber remains neat, so that the casting process can produce a relatively similar socket wall thickness in all parts.
f. After the outer reinforcement stockinette layer, a layer of protective plastic is given as much as 1 layer with a thickness (0.5-1.5) mm. This protective plastic coating aims to make the surface of the socket smooth and protect it from dirt from outside during the casting or lamination process. This protective plastic coating also aims to enable the vacuuming process during the lamination process. The vacuuming process is aimed to speed up the lamination process and eliminate the presence of voids.
g. The next step is to prepare a vacuum machine which will be used to assist the process of laminating the matrix mixture into the bamboo fiber layer. By using a vacuum machine, the lamination process can take place more quickly and the matrix can seep into the fiber layer more evenly. Likewise, the vacuum process can remove air trapped inside the layers of fiber and matrix, so voids do not occur.
h. After all materials and equipment are ready, lamination or casting process is carried out. This process begins with the pouring of the matrix mixture into the arrangement of socket material through the pouring channel. After the matrix mixture enters the pouring channel and begins to wet the composition of the socket material, a manual suppression process is carried out, so that the matrix mixture can seep into the socket material arrangement. At the same time, the vacuum engine is turned on and adjusted to a pressure of ± -50 bar for about 15 minutes, or during the casting process until all the matrix mixture has seeped into the socket material evenly and there is no visible air trapped.

**Figure 2.** Manufacturing process of socket

i. After the casting process is finished, the fabricated socket is allowed to dry using room temperature. This natural drying process at room temperature is better, when compared to the help of an oven. Although the drying process takes more natural time or ± (2-3) days, the quality of the resulting socket will be better from the surface and from the strength.

**Figure 3.** Socket product made from bamboo composites material

j. When the socket has dried, the socket is removed from the positive mold. This process must be done carefully because it can cause damage to the socket surface. After the socket is removed from the positive mold, the finishing process is carried out so that it is ready for testing or fitting to the prospective user. This fitting process is very necessary, especially to see whether the socket that has been generated matches the potential user's stump and a total socket contact occurs with the stump.
k. If everything is fine and suitable to the user's stump, the socket can be prepared for assembly into a single lower limb prosthesis with the other components, namely: shank, knee joint, foot and its connector.

The main load received by the socket is the compressive load that comes from the user's weight which is transferred via stump to the socket. Therefore, it is necessary to test the failure of the socket due to the load it receives. Socket is said to be safe if it can accept the burden of the user's body and added other expenses for safety. Maximum compressive strength testing is done to see the maximum load that can be accepted by the prosthesis socket until it runs into fatal damage. This test refers to ISO 10328. The testing process using a compressive test machine on the prototype socket and testing is done until there is a compressive failure on the socket [16-20].

**Figure 4.** Compressive failure testing of socket product

Based on the tests that have been carried out, the maximum load compressive strength test results on socket prosthesis products made from epoxy bamboo fiber composite are 87.1 ± 4.3 kN. This result is very good when compared with the weight of respondents in this study which is 63 kg or 630 N. With the failure of prototype socket prosthesis failure at 87.1 ± 4.3 kN, a high level of safety is obtained for the compressive load received. The results of morphological analysis using SEM showed that the manufacturing process that was developed had produced a good socket product and there was no void. Thus, the manufacturing process that has been developed can be a reference in making lower limb prosthesis socket products [16-20].

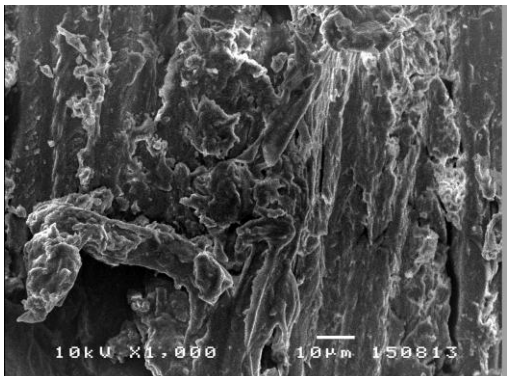


**Figure 5.** SEM result of socket prosthesis product made from bamboo composite material

## 4. Conclusion

Based on the results of the research and manufacturing of socket prosthesis products made from epoxy rattan fiber composites, it can be concluded that:

a. The manufacturing process procedures that have been developed include manufacturing bamboo fiber fibers, measuring the dimensions of stumps, making negative molds, making positive molds, lamination processes, finishing processes, fitting processes and prosthesis assembly processes. Each process must be carried out properly to produce socket products made from bamboo fibers that fit the patient's needs. Fiber lamination process uses an epoxy matrix with a ratio of 1: 1 and is added with a vacuum process so that it can accelerate the lamination process, epoxy resin absorbs well and removes voids.
b. The results of the compressive failure test of socket prosthesis products made from epoxy bamboo fiber composites show that the compressive strength produced (87.1 ± 4.3 kN) far exceeds the compressive strength requirements of the socket.
c. The results of morphological analysis with SEM show that the epoxy bamboo fiber composite material has a good interface and bond, and there were no voids. This will have a positive impact on the strength produced by epoxy bamboo fiber composites as socket prosthesis material.

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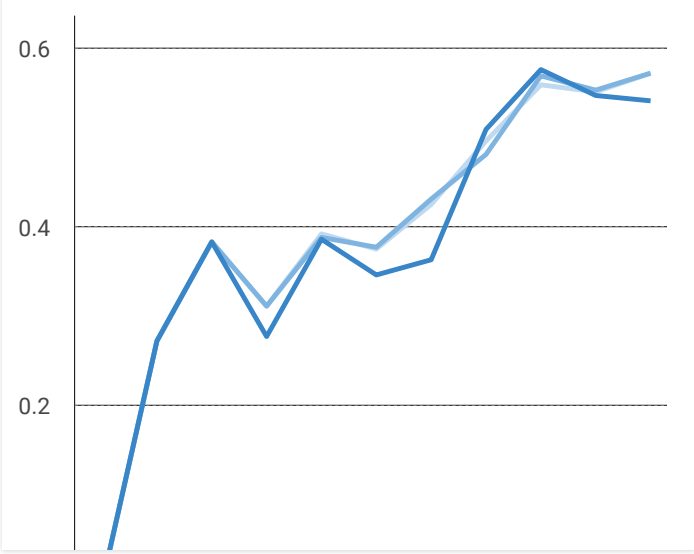


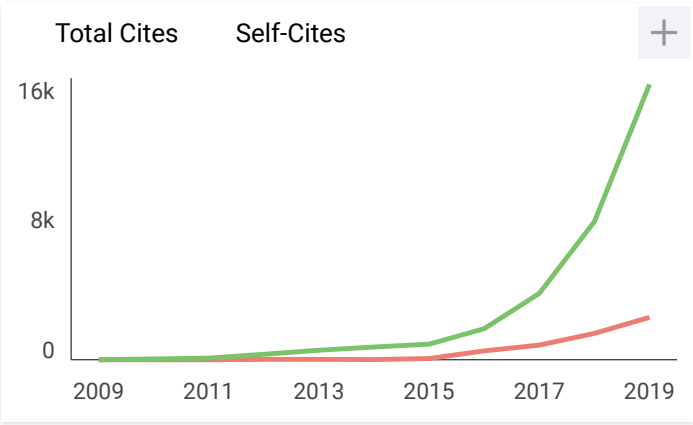


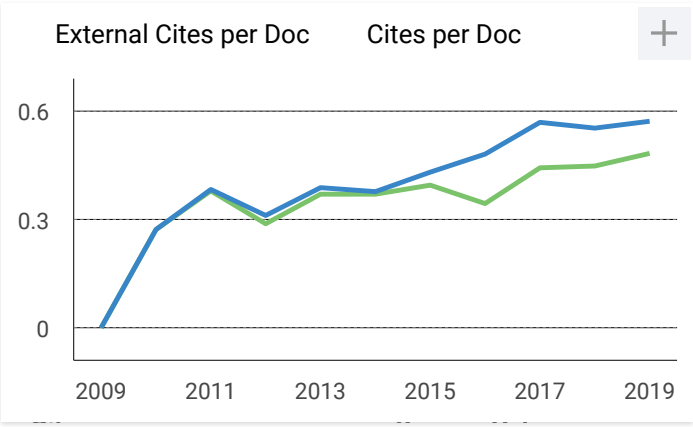


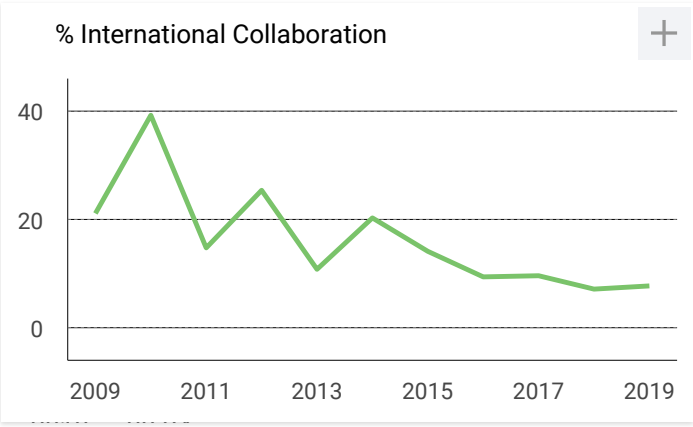


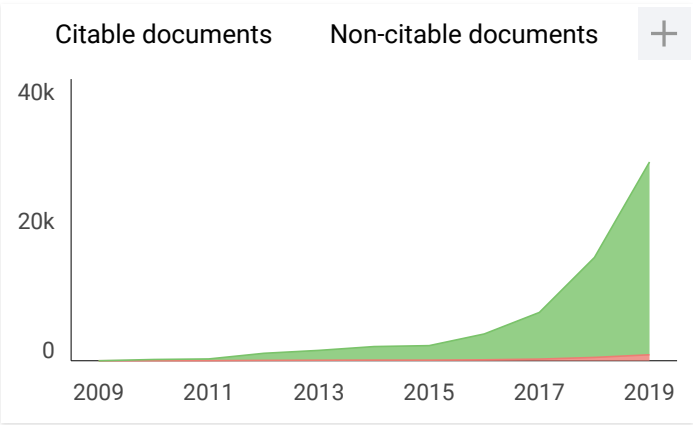


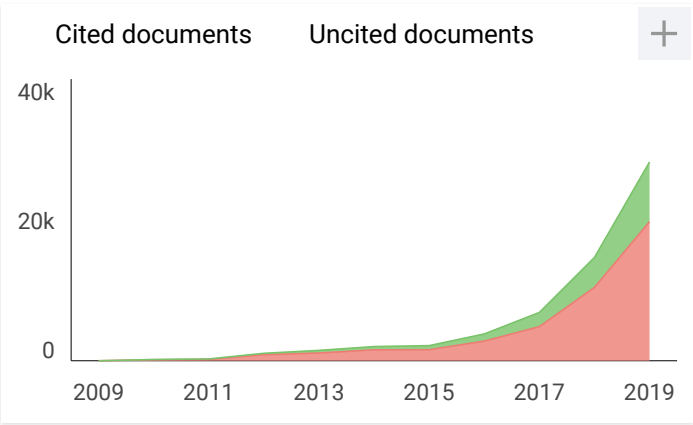



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