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# Revitalizing Balinese Woodcraft Industry Through Applying Nanocomposite Reinforced Synthetic Wood Technology

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***Abstract*—Our finding on a technology for producing woodcrafts using nanocomposite reinforced synthetic wood becomes an alternative solution for solving the current problems of Balinese woodcraft industries. The study on applying the current developed synthethic wood technology was conducted in order to analyze the production cost comparing toward the cost using natural wood, to gain the market responses for analyzing the comsumer satisfaction and the market competitive prices and to gain the stakeholders for innitiating a cluster industry. The costumer satisfaction as well as stakeholder acceptibility on the synthetic wood technology could revitalize the Balinese woodcraft industries.**

***Keywords*—nanocomposite; synthetic wood; woodcraft**

## I. INTRODUCTION

The trend of eco-labeling on industrial wood products such as woodcrafts and the increasing of people awarness on tropical forrest protection affected the world rejection of various natural woodcraft products from tropical countries, especially Indonesia. The reason is, according to State of World Forest Report, Indonesia has the 5th world widest rain forrest, but the forrest damaging rate is the 2nd world number [1]. Meanwhile, the wood plantation can not fulfill the massive increase of wood needs worldwide. Because of the lack of natural wood availability as the main raw materials of woodcraft industries and the rejection of tropical woodcraft by exported proposed countries, most of Balinese woodcraft industries have been facing a serious problem.

Synthetic woods made of cellulosic fibers from wood particles as well as lignocellulosic fibers from non wood particles were taken attention worldwidely since the first introduction of particle board from wood powder [2]. The synthetic wood technologies have been well developed since the finding of resinous addesives and the making procesesses of various kinds of synthetic woods.Commonly, the synthetic wood making processes were divided into three main processes, namely, dry, wet-dry, and wet processes [3]. The quality improvement of synthetic wood composites was further developed for fulfilling the application needs, such as stabilization from heat and sun rays damages [4], as well as enhancement of performance, strength, durability, weight, weather overcoming, and other properties [5-7]. Furthermore, the use of non wood cellulosic agrifibers [8-10]has some advantages such as their fast growing of plantation comparing to natural wood trees, their ability to give value addition of agricultural wastes, and environment friendly. However, they have also disadvantages such as the lack of strength as well as lack of ability toward fungies, weather, temperature, and sun rays. Thus, there is a need to improve the making processes such as the use of appropriate binder, the addition of reinforcer, as well as the improvement of texture and color.

Since the mapping of potencies of fifthteen high siliconeous tropical biomasses was reported [11], the silica-carbon nanocomposite from the rich silicon biomasses was produced and it was used for reinforcing the prototipe synthetic wood made of the lignocellulosic agrifibers [12-14]. The current study reported the initial industrial production of some Balinese synthetic woodcrafts that using the materials and technology as well as their commercialization processes for gaining the market and stakeholder responses.

## II. METHODS

### A. Making Some Balinese Woodcrafts

First, using triaxial blends of cellulosic fibers, silica-carbon nanocomposite, and resin and a process called moulding and casting was used for produsing some Balinese woodcraft. The composition of the blend and the processes of making synthetic woodas well as the the measurements of physical properties, namely density and moisture, were found elsewhere [12-15]. The mechanic properties of produced synthetic wood namely modulus of elasticity (MOE), modulus of rupture (MOR), and compresion parallel on grain were tested using ASTM 143-94 procedures and calculation. Universal testing machine (UTM) with 5 tonnes load was used for the testing of 5 synthetic wood samples.

### B. Market Survey and Innitating A Cluster Industry

A market survey was conducted by inviting some foreigners and domestic costumers candidates into a showroom located at Ubud area of tourisms for 2 months. The acceptibility concerning product quality and the selling prices some woodcrafts were compared towards the market prices of the market prices of the counterpart natural woodcraft products.

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Through a focus group discussion involving some stackholders, a cluster industry was designed and innitiated.

## III. RESULT AND DISCUSSION

There were 9 items of Balinese woodcrafts already produced, where each item was at least 2 sets (colored and non colored or original), namely Ganesha statue (non colored), Ganesha statue (acrilyc colored), horse statue (non colored), horse statue (acrilyc colored), komodo statue (non colored), Balinese carved door set (non colored), Balinese carved door set (prada colored), Balinese carved squared four pool Gazebo set (non colored), and Balinese carved squared four pool Gazebo set (golden colored). Because of synthetic wood thickness of proposed door set and Gazebo's four pool set, the mechanical properties such as MOE, MOR and compressive strength were measured. The results of measurements on physical and mechanical properties were shown on Table 1.

TABLE 1. PHYICAL AND MECHANICAL PROPERTIES OF SYNTHETIC WOODCRAFT

| No | Properties | Measurement Results |
|---|---|---|
| 1. | Density (g/cm$^3$) | 0.49 ± 0.01 |
| 2. | Moisture (% w/w) | 2.73± 0.02 |
| 3. | MOE (Kg/cm$^2$) | 110,673.40 ± 2,967.56 |
| 4. | MOR (Kg/cm$^2$) | 1,272.73±10.38 |
| 5. | Compressive Strength parallel to grain (Kg/cm$^2$) | 676.78±4.68 |

The results of physical and mechanical properties measurement showed that the synthetic wood was catagorized first grade quality at the Indonesian standard of construction woods according to the 1961 Indonesian Regulations of Construction Woods PKK NI-5 Peraturan Konstruksi Kayu Indonesia PKK NI – 5 published by the Directorate General of Cipta Karya, The Department of Public Construction of Republic of Indonesia. Compared to the properties of Merbau timber that have MOE, MOR, and compressive strength parralel to grain 162,728.43 kg/cm², 1,090.64 kg/cm², and 605.42 kg/cm² respectively [15], the values of MOE and MOR of the synthetic wood are of less quality than those of Merbau timber, however its compressive strength is better than that of Merbau timber. Compared to the proporties of two varieties of Teak timbers (Clone and Seeds) having MOEs (90,000 ± 9 kg/cm$^2$ and 108,000 ± 11 kg/cm$^2$), MORs (736 ± 26 kg/cm$^2$ and 941 ± 80 kg/cm$^2$) and compressive strength parallel to grains (203 ± 18 kg/cm$^2$ and 163 ± 9 kg/cm$^2$) respectively [16], the MOE and MOR values of the synthetic wood are higher than those of both Teak timbers varieties, however the compressive strength parralel to grain of the synthetic wood is lower than that of both Teak timber varieties. It means that the mechanical properties of synthetic wood is in between of Merbau and Teak timbers.

Results of production cost analysis showed that the cost of making synthetic woodcrafts in comparing with Teak woodcrafs is about 60-70% depending on the size and design complexity of products. It means that the synthetic woodcrafts are more efficients than that of Teak woodcrafts. The cost component of carving allowance for making carved woodcraft from Teak timber is the most contibution on the cost inefficiency comparing with the moulding technique that was used for making the carved synthetic woodcrafts. The need of time spans of skilled carverter is much reduced by the moulding technique.

Results of market feasibility analysis showed that the selling prices of the synthetic woodcrafts were30-50% cheaper that those of the counterpart natural woodcrafts as depicted on Table2.

TABLE 2. COST PRODUCTION (CP), FEASIBLE MARKET PRICE (FMP), BASIC SELLING PRICE (BSP), AND PRODUCT MARKET PRICE OF COUNTERPART NATURAL WOODCRAFTS (PMP-CNW)

| No | Woodcraft Products | CP (IDR. 1000) | FMP (IDR. 1000) | HPP (Rp. x 1000) | HPPP KA (Rp. x 1000) |
|---|---|---|---|---|---|
| 1. | Ganesha Statute (non colored) | 650 | 800 | 725 | 1,500 |
| 2. | Ganesha Statue (colored) | 950 | 1200 | 1,075 | 2000 |
| 3 | Horse Statue(non colored) | 275 | 700 | 487.5 | 1750 |
| 4. | Horse (colored) | 775 | 1,200 | 987,5 | 2500 |
| 5. | Komodo Statue (non colored) | 500 | 700 | 600 | 2500 |
| 6. | Carved Door Set (non colored) | 4,500 | 7,500 | 6,000 | 12,500 |
| 7. | Carved Door Set (colored) | 8,500 | 12,500 | 10,500 | 22,500 |
| 8. | Carved Four Pole Gazebo (noncolored) | 12,000 | 15,000 | 13,500 | 25,000 |
| 9. | Carved Four Pole Gazebo (colored) | 17,000 | 25,000 | 22,000 | 40,000 |

The 123 visitors of product showrooms consisting of public community (49%), entrepreneurs (32%), foreigners(19%) as currently published [17] concluded that 60% visitors gave responce on the market feasibility of the synthetic woodcrafts in catagory very good, 81% visitors wanted to buy the products in category was very high, and there were 77% visitors who stated their interest in getting involved in marketing the products in catagory very high. There are five main reasons why visitors interested in buying and/or getting involved in selling the synthetic woodcrafts, namely cheaper prices, environmental friendly, unique, and light. A product sample of synthetic woodcraft can be seen in Fig.1

Fig. 1 Synthetic Woodcraft of Horse Statues

Focus group discussion was held by inviting stackholders namely representatives from the Office of Industry and Trade Service Bali Province, representatives from the Local Office of Cooperation, Trade and Industry of Buleleng Regency, the representatives from the Buleleng Association of Small Industry Entreprises, and representatives from the Trade and Industry Chamberof Bali Province, along with representatives from Bali Zen Groups, entrepreneurs and mass media. The discussion focused on building a grand design of industrial cluster for the synthetic wood technology and their synthetic woodcrafts. They commited to sign memorandum of understanding (MoU) for involving the clusters depending on their potencies and rules.

The structure of the proposed cluster industry consists of (1) policy and infrastructure facilitator such as stackholders from government, mainly the Office of Industry and Trade Service, Directorate of Research and Community Services, and Governor Office as well as Regency Office, (2) funding facilitator from Bali Development Bank (Bank Pembangunan Daerah Bali), (3) science and technology developer (academicians from university), (4) design and artcrafts developers (academicians from art and design institute), (5) providers of raw and adding materials (PB. Suwela Amertha, Jagaraga Buleleng), (6) production of various synthetic woodcrafts (Rugos Art and Casting, Balipot, Wahyu Artha Handicraft, Siapa Sangka Handicraft and APIK Buleleng), and (7) marketing (PT. Sorga Indah, Bali Zen Group, CV. Citra Dewata and Krisna Oleh-Oleh). The schematic structure of the proposed cluster industry can be seen in Fig.2.

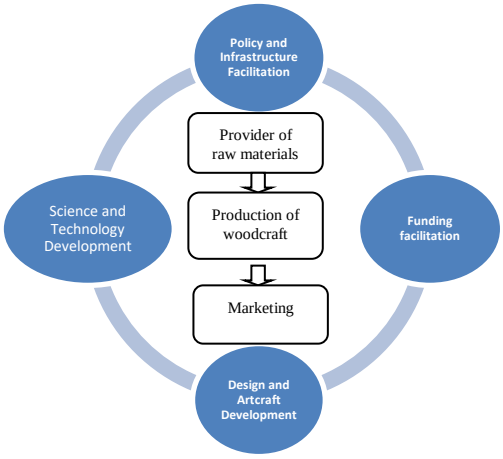


Fig.2. Schematic Representation of the Proposed Cluster Industry

## IV. CONCLUSION

The synthetic woodcrafts from high siliconeous agrifibers of tropical biomass have equal quality comparing with natural woodcraft products. The implementation of the synthetic wood technology is a strategic effort in revitalizing the current Balinese woodcraft industries because of its advantages in terms of cost production, value addition of agricultural wastes, environment friendly as well as time and cost efficiency.

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## REFERENCES

[1] A. Kurniasih. 2011. *BaliwoodBaligood*.Kuta: Wisnu Press.
[2] M. Himmelheber, Baiersbronn, Schwarzwald, K. Steiner, B.Tolz, and W. Kull. W., 1960. Methods and Apparatus for Producing Pressed Wood-Particle Panels, *United State Patent Office*, Number: 2923030.
[3] D. B. Good and L. B. Jones 1997. Method of producing fibers from a straw and board products made therefrom. *US Patent*. Number: US5656129 A.
[4] S. R. Kaspers, C. Guckel, D.Rogez, C. M. Schaller. 2011. Stabilization of Natural Composites. *United State Patent*, Number: US007862746B2.
[5] B. Nilsson. 2012. Particle Board. *United State Patent*. Number: US 20l202l767lAl.
[6] B. R. Davis, B. K..Buhrts, S. A.Haemmerle, W. G. Taylor, J. A. Alessandro. 2013. Composite Component Having Multilayer Cap. *United State Patent*. Number: US 20130052395A1.
[7] H. Rajaraman, S. J. Cranney, T. M. Majewski. 2012. Color Biofiber for Plastic Particles. *United State Patent*. Number: US008168697B2.
[8] R. E. Howard&K. E. Kaser. 1996. Thin Panels of Non-Woody Lignocellulosic Material. United State Patent. Number: US005498469A. March 12, 1996.
[9] J. R. Uhland, D. C. Smith, W. A.Farone. 2003.Production of Particle Board from Agricultural Waste. *United State Patent*. Number: US006596209B2, July 22, 2003.

[10] B. E. Zehner. 2005. Multilayer Synthetic Wood Components. *United State Patent*. Number: US006958185B1.

[11] I W. Karyasa. 2012.Meta-analisisTerhadap Material BerbasisSilikaTerbarukandariSekamPadidanPemetaanBiomassaTropis Kaya Silikon. *Prosidingdalam Seminar Nasional MIPA 2012*,Universitas Pendidikan Ganesha, 30

[12] I W. Karyasa, I W.,Muderawan, I MGunamantha,N M. Vivi Oviantari. 2016. NanokompositSilika-KarbonSebagaiPenguatKayuSintetikdariSeratLignoselulosaBerbahanBiomassaTropis Kaya Silikon. *Paten*. NomorPermohonan: P00201407241Tgl 21-11-2014, NomorPengumuman: 2016/00843 dengan BeritaResmi Paten Seri-A, Nomor: BRP477/II/2016, Tgl. 26 Februari 2016.

[13] Karyasa, I W.,Muderawan, I W., Gunamantha, I M. 2016. Renewable Silica-Carbon Nanocomposite and Its Use for Reinforcing Synthetic Wood Made of Rice Straw Powders, *KnE Engineering*, vol. 2016,6 pages. DOI 10.18502/keg.v1i1.522

[14] I W. Karyasa, I W.Muderawan, I M.Gunamantha. 2015. Silica-Carbon Nanocomposite from Bamboo Stems and Its Use for Reinforcing Synthetic Woods Produced From Lignocellulosic Agrifibers. *1st-International Conference on Inovative Research Across Descipline (ICIRAD)*, 18 Nopember 2015, Hotel Grand Inna Kuta Bali.

[15] F. S. Yoresta 2015. Pengujian Sifat Mekanik Kayu Merbau dari Daerah Bogor Jawa Barat. Jurnal Rekayasa Sipil. 11(2): 21-24.

[16] F. Hidayati, I. T. Fajrin, M. R. Ridho, W. D. Nugroho, S. N. Marsoem, M. Na'iem. 2016. Sifat Fisika dan Mekanika Kayu Jati Unggul "Mega" dan Kayu Jati Konvensional yang Ditanam di Hutan Pendidikan Wanagama, Gunung Kidul, Yogyakarta. *Jurnal Ilmu Kehutanan*. 10(2): 98-107.

[17] I W. Karyasa, I W.Muderawan, I M.Gunamantha. 2016. Respon Pasar Aneka Kerajinan Kayu Sintetik dari Jerami dan Sekam Padi yang Diperkuat Nanokomposit Silika-Karbon. *Seminar Nasional Riset Inovatifke-4Tahun 2016)*, 19Nopember 2016, Hotel Inna Grand Bali BeachSanur