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FABRICATION OF UNGLAZED CERAMIC TILE USING DENSE STRUCTURED SAGO WASTE AND CLAY COMPOSITE

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ABSTRACT

FABRICATION OF UNGLAZED CERAMIC TILE USING DENSE STRUCTURED SAGO WASTE AND CLAY COMPOSITE. In Indonesia, the sago processing industry generates every year huge amount of sago waste, and converting this waste into a useful material is possible. In the present study, physical properties of dense structured sago waste and clay composite were investigated in order to study the feasibility of reuse this sample as raw material in the producing of ceramics. Firstly, the chemical composition of ash (obtained from the sago waste) and clay was characterized. The prepared sample was sintered at the temperature range from 800 to 1,200 ^{o}C using electric furnace. The density, linear shrinkage and water absorption of the sintered sample were determined by using the Archimedes′ method. The experimental result indicated that the density of the sintered sample increased with increasing sintering temperature up to 1100 ^{o}C and then slightly decreased afterward. The water absorption of the products decreased with an increase in sintering temperature. In the sintered sample at 1,100 ^{o}C, the water absorption decreased rapidly and water adsorption of less than 1% was achieved. This water absorption was less than 5% which was needed for unglazed floor tile. The result of water adsorption suggest that it is possible to use this sample as a raw material for producing the ceramic floor tile.

Key words : Sago waste and clay composite, Ceramic tile, Water absorption, Density

ABSTRAK

FABRIKASI UBIN KERAMIK TAK MENGKILAP MENGGUNAKAN KOMPOSIT LEMPUNG DAN LIMBAH PADAT TERSTRUKTUR. Di Indonesia, industri pengolahan sagu menghasilkan limbah sagu yang sangat besar dalam setiap tahun dan memungkinkan untuk diubah manjadi bahan bermanfaat. Dalam penelitian ini, sifat-sifat fisik komposit lempung dan limbah sagu yang terstruktur padat diselidiki untuk mempelajari kemungkinan limbah sagu ini dapat digunakan lagi sebagai bahan baku dalam menghasilkan keramik. Sampel dipanaskan pada kisaran suhu dari 800 ^{o}C hingga 1.200 ^{o}C menggunakan tanur listrik. Kerapatan, penyusutan linier dan serapan air sampel setelah melalui proses pemanasan ditentukan dengan menggunakan metode Archimedes. Hasil eksperimen menunjukkan bahwa kerapatan sampel hasil pemanasan bertambah dengan penambahan suhu pemanasan sampai 1.100 ^{o}C dan hanya sedikit berkurang setelah itu. Serapan air produk berkurang dengan penambahan suhu pemanasan. Pada 1.100 ^{o}C, serapan air sampel berkurang dengan cepat dan diperoleh serapan air yang lebih kecil dari 1%. Serapan air ini lebih kecil dari 5% yang diperlukan untuk ubin lantai tak mengkilap. Dari hasil serapan air dapat diusulkan bahwa limbah sagu ini sangat mungkin digunakan sebagai bahan baku untuk menghasilkan ubin lantai keramik.

Kata kunci : Komposit lempung dan limbah sagu, Ubin keramik, Serapan air, Kerapatan

INTRODUCTION

In Province of Sulawesi Tenggara, Indonesia, the sago processing industries which are operated at small or medium scale, or even as a family business generates every year huge amount of sago waste. The residues from its production tend to be discharged to rivers. The disposal of sago waste become an importance problem, because the waste cause the health risk for public society, contamination to water sources and environment pollution. Safe disposal system or converting this waste into a useful is the possible way for controlling the

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pollution caused by this waste material. Recycling of this waste as a raw material in the production of ceramic is verry attractive because ash of this waste comprises of several inorganic component which are useful in ceramic product such as SiO_2, Al_2O_3, CaO, etc.

Moreover, reusing ash of this waste has many advantages such as reduction of the amount of residues and partial substitution of raw materials in industrial application [1,2]. Therefore, this waste is very potential to be developed for supporting the product of ceramic tile as a local resources based product of national ceramic in effort to optimalize the use of regional potential.

There are several points which have to be considered in providing ceramic bodies used for floor tile fabrication. Among them are the composition of a mixture of different raw material and the composition of chemical constituents. Floor tile is a ceramic material primarily composed of clay, carbonate and quartz [3]. The intention of using clays as a raw material for ceramic has become increasing because in addition to its cheap price and common minerals, clays are also the plastic materials that have the main function to supply plasticity and to provide adequate mechanical strength for both, the green and the dried body pieces. Carbonate is to decrease the plasticity and quartz is to improve the mechanical strength.

In reality, the blend of clay, carbonate and quartz have still some technical issues in application for fabricating floor tile. The detailed analysis [4-5] of the experimental data shows that the excessive plasticity can result in problem at the forming stage and make it difficult to achieve the required body permeability. Other critical issues are that the high amount of Fe_2O_3 of clay can result in undesired color for the ceramic support, while the carbonates such as calcite and dolomite of its mixture can decrease the fluxing action and the moisture expansion. Therefore, the proper selection of raw material is very important for further ceramic development.

EXPERIMENTAL METHOD

Sago wastes that consist of fine and coarse hampas (solid residue which is left behind after the starch has been washed out) were obtained from the sago processing plant in Kendari, Indonesia. The clays in the present investigation were obtained from the rural area of Sindangkasih, located in Konawe Selatan, Indonesia. These materials for the samples were selected manually, cleaned and dried in an oven at temperature of 105 °C for 24 hours.

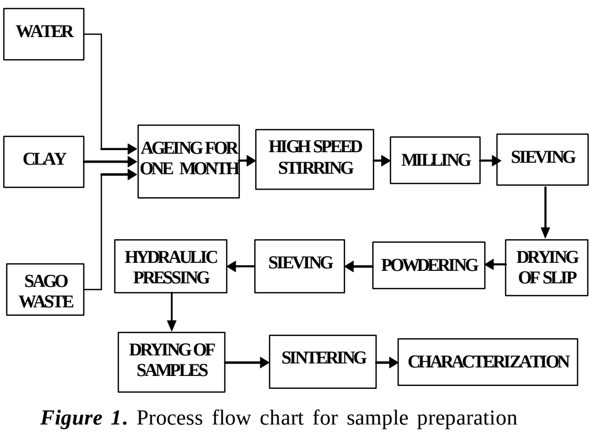

Figure 1. Process flow chart for sample preparation

Figure 1 shows process flow chart for sample preparation. The mixture of sago waste (50 wt.%), clay (50 wt.%) and water was kept under ageing for one month and stirred well with high speed stirrer before pot milling. The mixture was milled for a time period of 6 hours. For powdering, the samples were dried in oven at 105 °C for 24 h. After powdering the dried mass, cylindrical sample of 20 mm in diameter and 7 mm in thickness were prepared at a pressure of around 11 MPa by hydraulic compaction. The sample was dried at 600 °C with drying rate of 1.47 °C/min and then kept constant for 2 hours in an electric furnace. The sample was sintered at temperature in the range of 800 °C to 1200 °C using an electric furnace device. A controlled heating rate of 2.08 °C/min in an electric furnace was maintained up to the desired temperature and the temperature was kept constant for 2 hours. The cooling was performed by natural convection after turning EF off and leaving the sample inside.

The evaluated properties were density, linear shrinkage and water absorption. The density, linear shrinkage and water absorption of the sintered sample were determined by using the Archimedes method.

RESULTS AND DISCUSSION

As illustrated in Table 1, the chemical composition analysis of sago waste sample show that silicon oxide

Table 1. Chemical analysis of sago waste ash and clay

Major chemical constituents (wt.%)	Ash of sago waste	Clay
SiO_2	68.03	60.53
Fe_2O_3	0.759	2.00
Al_2O_3	6.93	25.27
CaO	14.88	0.05
MgO	2.39	0.66
Na_2O	1.35	1.38
K_2O	1.35	3.73
P_2O_5	1.66	0.036
TiO_2	0.03	0.744
SO_3	2.02	-
MnO	0.646	0.005
NiO_2	0.02	0.002
Cr_2O_3	0.04	0.008
LOI	-	5.37

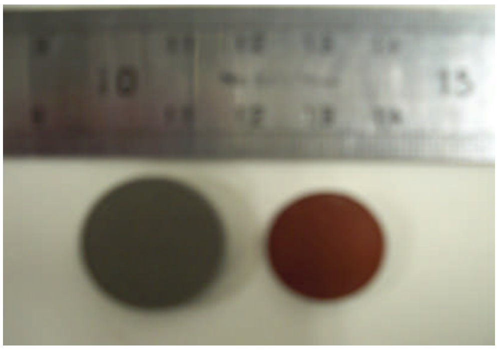

Figure 2. Change of green sample diameter and the formed ceramic bodies at temperature of 1.100 ^{o}C.

(SiO_2) and calcium oxide (CaO) was the most abundant component. The high component of the calcium oxide is associated with the presence of calcium carbonate. Thus, sago waste sample can be considered from a chemical viewpoint, a pure relatively natural carbonate based material as required in the fabrication of the floor tile. The clay contains about 2% of Fe_2O_3. The percentage of Fe_2O_3 in clay of less than 3% is needed for ceramic [4]. The amount of Fe_2O_3 in this clay sample do not influence the nature of color for ceramic body.

The porosity of the sintered samples is associated to linear shrinkage and water absorption. Figure 2 shows the change in diameter of the green (before sintering) and the formed ceramic (after sintering) bodies. The diameter of the ceramic body is less than the green body as a consequence of sintering temperature. It can be also seen that the color of the formed ceramic body was different from the green body. The change of diameter is associated to the linear shrinkage.

Figure 3 shows the linear shrinkage of ceramic samples prepared from sago waste and clay composite. It can be seen that the linear shrinkage increases and reaches a maximum value at 1.100 ^{o}C. It can be attributed to the formation of a liquid phase that fill the porosity. Above 1.100 ^{o}C, linear shrinkage decreases due to close porosity increasing. It has been observed that density has a similar behaviour than linear shrinkage.

Figure 4(a) and 4(b) show the density and water absorption of the formed ceramic body prepared from sago waste and clay composite, respectively. The ceramic

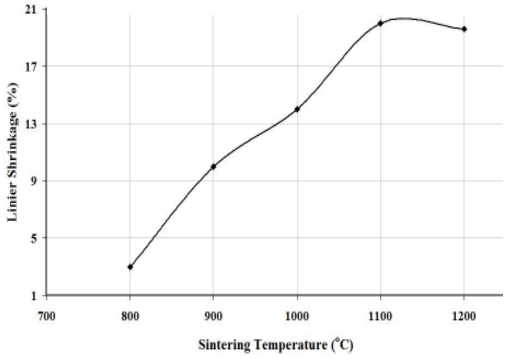

Figure 3. Linear shrinkage of the formed ceramic body prepared from sago waste and clay composite

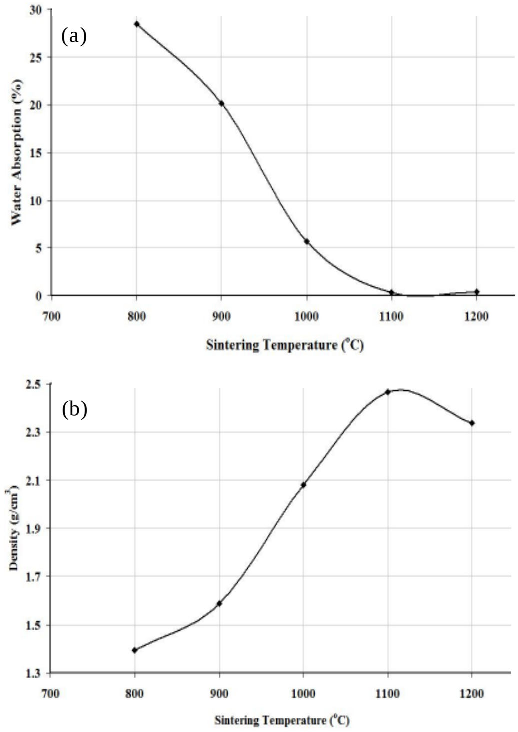

Figure 4. (a) Water absorption, and (b) Density of the formed ceramic body prepared from sago waste and clay composite

water absorption initially decreased and then increased, while the density initially increased and then decreased. The sintering temperature was optimum when water absorption was the lowest and the density was the highest. The behavior of water absorption explains that at an elevated sintering temperature, the pores inside ceramics became smaller, resulting in a decrease in water absorption and an increase in density before the temperature reached the optimum sintering temperature. When the firing temperature was higher than the optimum sintering temperature, the air pressure in the enclosed pores increased quickly leading to an increased pore size and porosity, and to an expansion of the ceramics resulting in an increase in water absoption and a decrease in density. In DIN standard, the water absorption of less than 5% is needed for unglazed floor tile [6]. According to this standard, the water absorption of the sintered sample at sintering temperature of 1.100 ^{o}C were in the range.

CONCLUSION

Physical properties of ceramic samples prepared from sago waste and clay composites were investigated and the results demontrated that physical properties depended on the sintering temperature. Sago waste and clay composites, which were sintered at temperature of 1.100 ^{o}C have minimum water adsorption and maximum density. The result of water adsorption suggest that it is possible to use sago waste as a raw material for producing the ceramic floor tile. Further, the surface

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morphology and flexural strength of this sample is under study. We have been preparing sago waste and clay composites for producing unglazed ceramic tile using microwave sintering in Laboratory of Material and Ceramic, Department of Physics, Faculty of Mathematics and Natural Sciences, University of Haluoleo.

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