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Preparation and Characterization of Ceramic Products Using Sugarcane Bagasse ash Waste

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Abstract

Bagasse ash is a waste from the burning of bagasse for power generation in sugarcane industry. Ash has a high silica with smaller amount of aluminium, iron, alkali and alkaline earth oxides. In this study an attempt has been made to use this waste ash as a partial replacement of ceramic body (Clay, Feldspar, Quartz) by different weight percentage are used to produce ceramic specimen. The chemical composition of the samples was determined by using XRF. Each composition was milled in a ball mill to obtain a suitable homogenous powder for specimen preparation. The green specimen was sintered under controlled temperature. The manufactured specimen was tested for its quality assessment. The observed mechanical parameter and analytical results of the specimens were correlated with the reference. The investigation reveals that high quality ceramic specimens could be achieved from blended materials. Thus, sugarcane bagasse ash waste presents high potential for application in the manufacture of ceramic products.

Keywords: Bagasse ash, ceramic insulator, properties, microstructure.

Introduction

In sugar mill, bagasse is a residue after the sugarcane juice extraction. Baggase is used as a fuel in boilers for thermal power generation in the same industry. The ash produced in this process is called as bagasse ash. The sugarcane bagasse ash (SCBA) waste can be characterized as a non-biodegradable solid waste material rich in crystalline silica and aluminium, calcium, iron, potassium and magnesium oxides are the main minor components[1-3].

As a result, the sugarcane industry generates large volume of bagasse ash waste worldwide. The management of this abundant waste in an environmentally safe way is challenge that must be met. Some researches[4-5] showed that SCBA needs to calcined to be active and can be classified as pozzolanic material and they have reported that the SCBA burned at 650 ºC and ground is a better blendes than other mineral admixtures.

To recycle the waste material in ceramic industry is an advantage of environmental protection and also saving the raw materials. Ceramics is used as a insulating materials. The advantage of ceramic insulators are better electrical properties, absence of deformation under stress at room temperature and greater resistance to climate changes. Ceramic insulators are widely used in the microelectronic devices as well as in power transmission lines [6-7].

Aim of the study is to develop the bagasse ash blended ceramic products (Porcelain electrical insulator) and to investigate the effect of baggase ash (waste material) on the physical and microstructural properties of the resultant product are also investigated.

Material and Methods

Experimental Procedure: For this investigation sugarcane baggse ash and ceramic body (Clay, Quartz, feldspar) only used. Sugarcane bagasse ash waste was collected from the Chengalvarayan Co-operative sugar industry, Periyasevalai, Thirukovilur Taluk, Tamilnadu. The standard ceramics material compositions [Clay (50%), Quartz (15%), Feldspar (35%)] are collected from M/S. Oriental Ceramic Industry, Viruthachalm. Sugarcane bagasse ash was cleaned, dried and calcined through a heating rate of 300 ºC / hour and than held at 650 ºC for 2 hour. At 500 ºC, the organic compounds decomposed off and at 650 ºC large amount of ash (BGA) with high active silica content was obtained[8]. The oxides composition of the raw materials is given in Table-1

Partial replacement the feldspar by a treated bagasse ash (BGA) waste in porcelain body for preparation of two different porcelain insulator and thus composition is provided in Table-2. The sample preparation procedure for the sintered electrical insulator is given in figure-1

Table-1
Oxide compositions (wt%) of the raw materials

Composition	Clay	Quartz	Feldspar	BGA
SiO_2	62.75	97.50	64.10	69.81
Al_2O_3	29.73	0.82	13.96	6.73
Fe_2O_3	3.17	0.17	0.28	4.35
CaO	0.31	0.13	0.50	9.40
MgO	0.37	0.03	0.18	2.42
K_2O	1.02	0.31	16.74	2.65
Na_2O	0.25	0.20	2.80	0.71
TiO_2	1.52	0.02	0.15	0.42

Table-2
Constituent (%) of ceramic products

Batches	B_0	B_{20}
Clay	50	50
Quartz	15	15
Feldspar	35	15
BGA	0	20

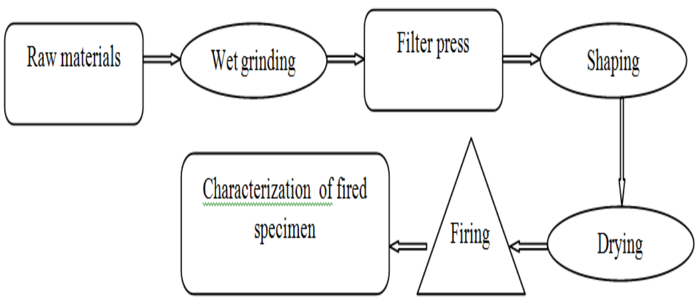


Figure-1
Flow sheet for preparation of porcelain insulator

The manufactured specimens were tested for its quality assessment. Physical properties (porosity, water absorption and bulk density) of the specimen were conducted by boiling water method. Dielectric strength determination[9] was carried out using a variable transformer to obtain the voltage gradient at which electric failure occurs at. Microstructure of the specimen was observed by using JEOL –JSM-5610LV Scanning Electron Microscope available at CISL, Annamalai University.

Results and Discussion

The quality of the porcelain ceramic insulator fired at 1250 ºC was determined on the basis of water absorption, porosity and bulk density carried out according to ASTM, 1985a[10]

Porosity, water absorption, bulk density: The boiling method was used for this test at 100 ºC for 2 hours. The specimen was subjected to 1 hour boiling followed by an additional two hour water soaking and then weighed as W_{sat}. The soaked specimen was then suspended from the beam of a balance in a vessel of water so arranged that specimen was completely immersed in the water without touching the side of the vessel. The suspended specimen in water weighed as W_{sus}. Porosity was then calculated by the equation(1).

$$\text{Porosity (P)} = \frac{W_{sat} - W_d}{W_{sat} - W_{sus}} \times 100\% \tag{1}$$

where, W_{sat} = Saturated weight, W_d =Dry weight. W_{sus} = Suspended immersed weight.

The calculated porosity (%) of the sample B_0 and B_{20} is shown in figure-2. It is observed that percent porosity B_{20} is significantly lower compared to B_0 and this is very advantages for electrical insulator product. This may be due to the presence of active silica in treated begasse ash . It is well coincided with the SEM micrographs.

Water absorption: Water absorption is related to the microstructure of a sintered ceramic matrix, and evaluates the open pores amount of the fired specimen. Water absorption was then calculated by the equation(2).

$$\text{Water Absorption} = \frac{W_{sat} - W_d}{W_d} \times 100\% \tag{2}$$

The water absorption value decreases in bagasse ash blended porcelain material. The lower range of water absorption percentage in B_{20} indicates better vertification[11] than B_0. The amount of water absorbed by the material in service will affect the service life of the material and even reduce the resistivity of the material. Therefore, absorbed water reduces the insulation resistance.

Bulk Density: Bulk density was calculated using a direct volume measurement method. This method exploits the relative density of a substance multiplied by the density of water to obtain the required bulk density. Equation (3) was used to obtain the bulk density in g/cm^3.

$$\text{Bulk Density} = \frac{W_d}{W_{sat} - W_{sus}} \times \text{Density of Water (g/cm}^3\text{)} \tag{3}$$

The bulk density of the sample B_{20} (2.39 g/cm^3) is slightly higher than B_0 (2.06 g/cm^3). This is related to the vertification that contributes to an open pores amount that reduced resulting is more dense porcelain insulator.

Dielectric strength: Dielectric strength is an important ceramic insulator property and measured through the thickness of the samples. Strength is possible by increasing the voltage on the variable transformer from zero at a predetermined speed of 1000 volts per second to break down. At the break down voltage, the equipment automatically switched off. The dielectric strength is expressed in volts per unit of thickness.

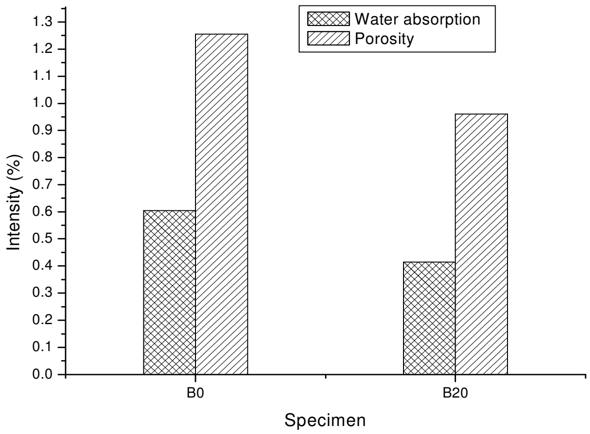
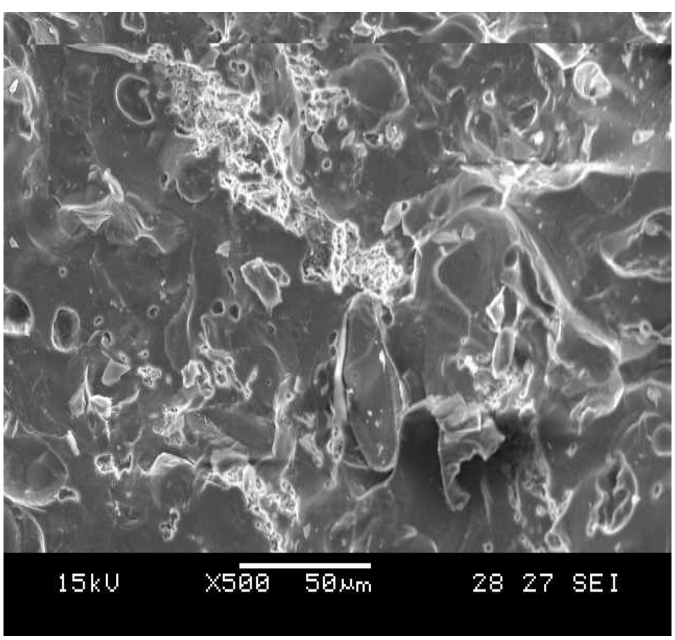


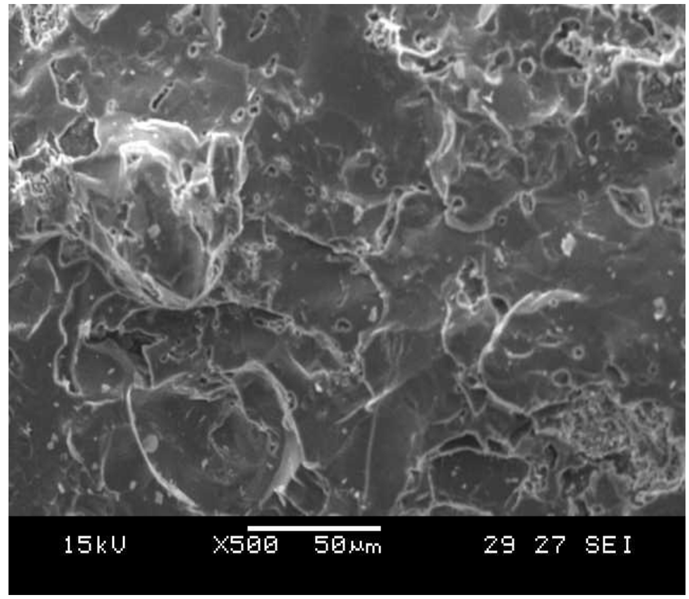
Figure-2
Water absorption and Porosity of porcelain insulator

The dielectric strength of the specimen was measured at room temperature and at 40% relative humidity with a puncture test. The dielectric strength values of the samples B_{20}(8.2 kV/mm) is higher than B_0(7.1 kV/mm) are with in the range of 6.0 to 13 kV/mm, which is the specified range of porcelain insulator[12]. The dielectric strength increased with addition of BGA in the porcelain insulator.

Morphology: The microstructure of the fractured surfaces ceramic insulator B_0 and B_{20} are shown in figure-3a and 3b respectively. The correlation between fractured microstructures and technological properties is well established[13].



(a)



(b)
Figure-3
SEM images for fracture surfaces of the porcelain insulator (a) B_0 and (b) B_{20}

In figure -3a, the fracture surface is rough and the pores are clearly visible. These are seen to be spherical, elliptic and homogenously distributed in the matrix, while a few pores are elongated and interconnected. 1-10 µm size of the pores are observed.

In Figure -3b, elimination of a large number of pores that exists within the structure occurred. In addition, the vertification is in progress. In fact the glassy phase cause densification via liquid phase sintering. This justifies the improved technological properties of the bagasse ash blended insulator.

Conclusion

Physical, microstructural and electrical breakdown strength of porcelain insulator with baggase ash blended have been studied. Sample with 20% baggase ash content resulted in lower porosity, water absorption and higher dielectric strength compared to standard porcelain insulator. The results produced in this investigation confirm the bagasse ash based porcelain electrical insulator can be successfully made. Hence, economical potential waste bagasse ash can be reused.

Acknowledgements

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