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Effect of bagasse ash on some refractory properties of Alkaleri clay (Alumino-silicate)

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ABSTRACT

The possibilities of upgrading some refractory properties of Alkaleri Clay, found in Alkaleri village, Bauchi State, Nigeria, by blending with bagasse ash production of fire clay refractory bricks were investigated. Refractory properties such as: linear shrinkage, apparent porosity, bulk density, cold crushing strength and thermal shock resistance were tested with percentage additions of bagasse ash from 5-25% in the blend. The test was conducted using the standard test techniques in each case. The results were compared with standard refractory properties for fire clay bricks. Linear shrinkage, apparent porosity of the bricks made from the blend clay decreased, as the percentages of bagasse ash increased. The cold crushing strength and thermal shock resistance increased as the percentages of bagasse ash addition increased. All the values obtained from the blends are within the recommended values for dense fire clay bricks.

KEYWORDS

Alkaleri Clay;
Bagasse ash;
Refractory properties.

INTRODUCTION

A refractory material is one which has the ability to withstand high temperature without breaking of deforming. Refractory products are used wherever high temperatures are required and include refractory bricks for furnace linings, tubes for electric furnaces, crucibles, thermocouple sheaths, refractory cements, among others. The classifications of refractory materials according to their chemical nature are basic, neutral and acid refractories[1, 2]. The more important characteristics which are required of a refractory are[3]:

a) High melting point or high refractoriness, which is closely related to thermochemical stability.
b) Mechanical strength at high temperature in terms of high refractoriness under load, high thermal shock resistance, low thermal shrinkage, low porosity and permeability.
c) Resistance to chemical attack in the particular situation in which it is used, for instance, high resistance to corrosion by slags.

Refractories are considered as inorganic materials, mainly of mixtures of oxides, obtained for naturally occurring minerals, which are capable of withstanding very high temperature condition, without any undue deformation, softening, change in composition, they include silica, magnetite, chrome, carbon, dolomite, alumino-silicates[4]. Most industries dealing with the treatment of ores and other materials for the manufacture of metallurgical, chemical and ceramic products operates at a very high temperature condition so, the equipment used for the treatment of this materials must sustain the operating temperatures and other working condition such as erosive and local conditions. In the metallurgical industry, the most commonly used refractory include chromite, dolomite, magnetite, chrome magnesite, silica and alumino silicate clays $(Al_2Si_2O_5)(OH)_4$. Others include fosterite, zircon refractories, zirconia refractories[5].

Bagasse can be found in many locations around the world including the northern region of Nigeria. Bagasse is the residue fiber remaining when surgar cane is pressed to extract the sugar. Some bagasse is burned to supply heat to the sugar refining operation. Some is returned to the fields, and some finds it way into various board products[6]. Until recently, the remaining 90% (empty fruit bunches, fibers, fronds, trunks) was discarded as waste, and either burned in the open air or left to settle in waste ponds. This way, the Sugar-cane processing industry's waste contributes significantly to CO_2 and methane emissions. Bagasse is available wherever sugarcane is grown. As such, almost no harvesting problems exist, and large volumes are available at sugar mills. In northern climates, the cane harvest usually lasts about 2.5 months. In warm climates, bagasse may be available for as long as 10 months out of the year. During this time, bagasse supply is relatively constant: the remainder of the year, it must be stored. To reduce the sugar content and increase storage life, bagasse is usually depithed before storage. The pith is an excellent fuel source for the sugar refining operation[6]. Recent research on the potential utilization of bagasse ash by[6] showed that the mineralogical content of bagasse ash are C, SiO_2, SiC and Ti_6O as the major constituents and the minor ones are Fe_2O_3, Na_2O, CaO and MnO(see TABLE 1). This mineralogical content confirmed that bagasse ash can be used as refractory materials[6].

Earlier works on Alkaleri Clay(Alumino-Silicate) deposit showed that it has low spalling resistance and high apparent porosity[1], which is not satisfactory, hence there is need, to improve the refractory properties of this clay. It is the light of the foregoing that the research on the investigation of the effects of bagasse ash on some refractory properties of Alkaleri clay was motivated.

TABLE 1 : Identified Patterns List of the XRD of bagasse ash[6]

Visible	Ref. Code	Score	Compound Name	Displacement [°2Th.]	Scale Factor	Chemical Formula
*	00-041-1487	31	Cliftonite	0.000	0.657	C
*	01-085-0798	30	Quartz	0.000	0.084	SiO_2
*	01-075-1541	19	Moissanite 6\ITH \RG	0.000	0.044	Si C
*	01-072-1807	18	Titanium Oxide	0.000	0.045	Ti_6O

EXPERIMENTAL PROCEDURES

Collection of clay samples

As-mind samples of Alkaleri (Bauchi clay) was collected from the stockyard of the refractory department of the National Metallurgical Development Center, Jos, Nigeria. The average size of the samples were between (20-30cm). TABLE 2 showed the composition of the clay[2, 5].

The bagasse used in this work was obtained from Zaria in Kaduna-State Nigeria(see Plate 1). The bagasse was then carbonized at 1200°C for 5hours to obtain a black color ash and sieve to average particle size of 63μ m(see Plate 2).

Preparation of the clay

The raw clay was soaked in water for three days

TABLE 2 : Chemical compositions of Alkaleri Clay[2, 5]

Refractories	Chemical Compositions (%)									
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	ZrO_2	TiO_2	L.O.I
Alkaleri Clay	56.50	24.95	Nd	1.00	2.32	Trace	Trace	Nd	Trace	15.32

a) Bagasse

b)Bagasse ash

Plate 1 : Photo of Bagasse and Bagasse ash

and dried in open air for a week, this treatment was necessary to remove alkalis, and some dead organic matters. The presence of alkalis, sodium and potassium, retard mullite formation and hence lowers the refractoriness and strength of the clay[7]. The dried clay was then crushed and ground into powder form using jaw crushers and pulverizing machine. The ground clay was sieved to pass through sieve 300um aperture.

Brick production

Preparation of the test samples involved mixing of the freshly sieved clay with varied percentage of bagasse ash between 5-25%. The clay mixture was found to be plastic at 10% water content level. The mixed blend was packed into a metal moulding box and pressed using hydraulic press. A pressure of 15kg/cm^2 was applied to enhance homogeneity and surface smoothness of the samples.

The mould bricks were dried in open air for three days, followed by drying in oven for 12 hours at 110°C to expel any moisture left in the bricks and to avoid crack during firing. Firing was carried out in electric heating furnace pre set at heating rate of 7°C/minute. The firing procedure used involved heating and soaking the samples at various temperatures that is: 250°C for 6 hours, 650°C hours for 4 hours, 950°C for 3 hours, 1100°C hours for 8 hours and 1600°C hours for 8hours. After firing the bricks were then allowed to cool in the furnace at a cooling rate of 1°C /minute[5].

Test procedure

The fired bricks were tested for linear shrinkage, apparent porosity, bulk density, cold crushing strength and thermal shock resistance according to the recommended standard.

Linear shrinkage

The green and fired dimensions of the bricks were measured and record using veniar caliper. The linear shrinkage was then calculated as a percentage of the original wet length as shown below[5]:

Percentage of fried shrinkage = $\frac{l_b - l_c}{l_b}$ **x100(%)**

l_b— dimension of green bricks

l_c— dimension of fired bricks

Apparent porosity and bulk density

The fried brick was kept in the oven at 110^{O}C for 3 hours to obtained constant weight D the brick was then suspend in distilled water and boiled on a hot plate for 30 minutes, after boiling, while still in hot water, the water was now displaced with cold water and the weight W was measured on a spring balance hinged on the a tripod stand. The test samples were removed from the water and extra water wiped off from the surface by lightly blotting the sample with wet towel and the weight S in air was measured, the apparent porosity (P_a) of the bricks was determined from the relationship[5].

$$P_a = \frac{W - D}{W - S} \text{x100(\%)}$$

Pa=apparent porosity

The Bulk density (B_d) was also calculated from the relationship as

$$Bd = \frac{D}{W - S} \ (g\backslash cm^3)$$

Bd=bulk density, D = Dried weight, W = Soaked weight, S = Suspended weight

Cold crushing strength

The fried bricks were tested for crushing strength using hydraulic strength testing machine. The crushing strength was then calculated using the relationship[8]:

$$\text{Cold Crushing strength} = \frac{\text{load(KN)}}{\text{Area}(m^2)}$$

Thermal shock resistance

A thermal shock resistance test samples were put in furnace that was maintained at a temperature of 1300^{O}C and soaked at this temperature for 30mintues after this the brick was brought out to cool for 10 minutes. The brick was then tested for failure using a standard rig, if failure did not occur the brick was then put back inside the furnace and heated for a period of ten minutes, this cycle of heating, cooling and testing was repeated

Until failure occurred. The number of complete cycles to produce failure in each sample was noted.

RESULTS AND DISCUSSION

Results

The results of the studies are showed on Figures 1-5 and TABLE 3 showed the standard properties of Indian fireclay refractory[4], TABLE 4 showed the standard properties of some Nigerian clay as Refractory materials[8].

Discussion

The linear shrinkage of 100% Alkaleri clay was found out to be 5.67%. On addition of 5% bagasse ash, there was decrease in the linear shrinkage from 5.67% to 5.00%. This decreased continuously beyond this level up to 2.17% at 25% addition of bagasse ash (see Figure 1). This is expected because addition of bagasse ash being finer in grain size than the clay is

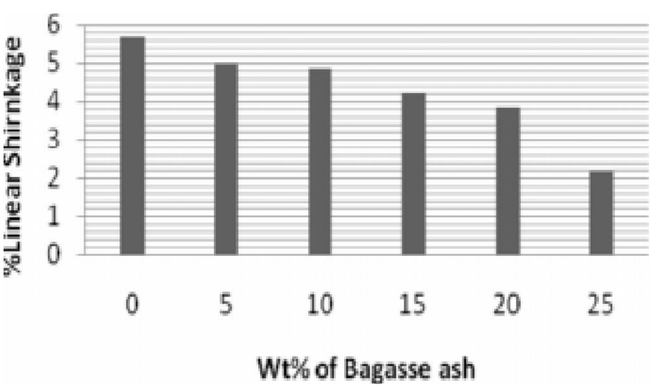

Figure 1 : Variation of % Linear Shrinkage with Wt%Bagasse ash

going to reduce the number of pores in the produced bricks resulting in small dimensional changes after firing and removal of water hence low linear shrinkage values. However, the addition of the bagasse ash has increased the dimensional stability of the bricks which is also very important.

The apparent porosity of the bricks made from 100% clay was 35.00%. This decreased to 30.65% at 5% additions of bagasse ash. This decreased continuously beyond this level to 22.17% at 25% additions of bagasse ash(see Figure 2).

Figure 2 : Variation of % Apparent Porosity with Wt%Bagasse ash

This result is as expected because there exists a direct relationship between the linear shrinkage and porosity and it is expected that good firing shrinkage(low linear shrinkage values) would result in closure of internal pores and hence leading to reduction in apparent porosity of the bricks[1,2]. The addition of the bagasse ash being finer in grain size is expected to result in fewer pores hence low values of apparent porosity for the bricks so produced. Hence the porosity of the bricks found from the blends fall within the acceptable level as

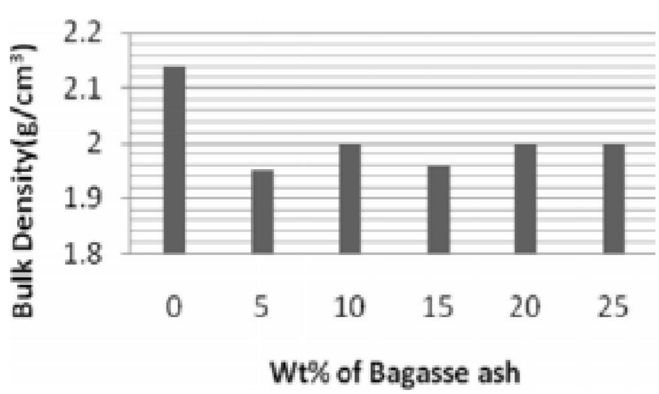

Figure 3 : Variation of Bulk Density with Wt%Bagasse ash

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recommended for dense fireclay bricks(see TABLES 3-4).

The bulk density of the blend is between 1.92 – 2.4 g/cm^3 (see Figure 3).

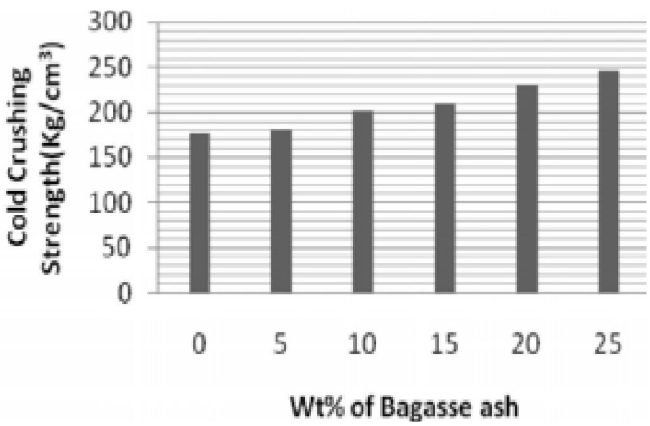

Figure 4 : Variation of Cold Crushing Strength with Wt%Bagasse ash

TABLE 3 : PROPERTIES OF INDIAN FIRECLAY REFRACTORY

TYPE	Refractoriness	Apparent Porosity %	Bulk density gm/cc	Crushing Strength kg/cm^2	Thermal shock resistance
Medium heat duty	1655	22-25	1.95-2.05	200-250	Good
High heat duty	1699-1717	23-26	2.00-2.10	170-230	Good
Super heat duty	1743-1763	15-16	2.15-2.25	400-600	Good
I Ii	1743-1763	18-20	2.10-2.20	250-300	Excellent

Source: Chest[4].

The values of bulk density on addition of bagasse ash is expected because addition of bagasse ash closes the pores resulting in decrease in the pore volume hence increasing the bulk density. All the values are within the standard recommended value for fire- clay since the typical value of bulk density for dense fire clay bricks was around 2.3 g/cm^3 (see TABLES 3-4).

The cold crushing strength value for 100% Alkaleri (Bauchi clay) was 175.00 Kg\cm^2 this increased to 245.65Kg\cm^2 at 25% additions of bagasse ash (see Figure 4). On addition of bagasse ash the cold crushing strength increases this is expected because bagasse ash is harder and fine grained in nature than the clay giving bagasse ash-clay masses an excellent rate of sintering hence resulting in high cold crushing strength. It is clear that the additions of bagasse ash to Alkaleri (Bauchi clay) improved the clod crushing strength. This agreed with the standard cold crushing strength of 200-250Kg\cm^2 minimum for fireclay (see TABLE 3).

The 100% Alkaleri (Bauchi clay) and 5% additions of bagasse ash were poor at 1300 ^{O}C. There is increased in the thermal shock resistance of the bricks as the addition of bagasse ash is increases to 10-25% at 1300 ^{O}C since this blends fall within the acceptable ranges of 15+ cycles. Only the 25% addition has the highest number of cycles that is 25(see Figure 5). This might be due to the fact that no degree of fusion might have taken place. Higher percentage of bagasse ash beyond 25% in the blend might have resulted in excellent thermal shock resistance.

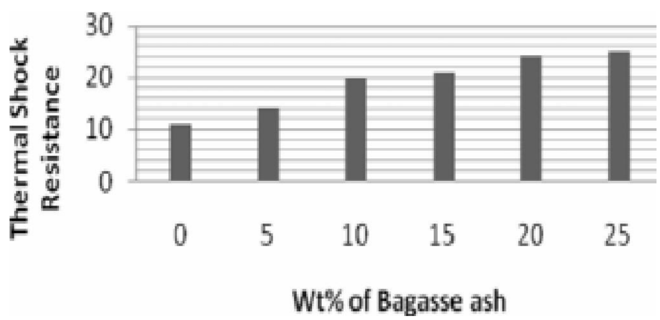

Figure 5 : Variation of Thermal Shock Resistance with Wt%Bagasse ash

TABLE 4 : PHYSICAL PROPERTIES OF CLAY SAMPLES

Sample location	Bulk Density g/cm^3	Apparent Porosity %	Permeability	Linear Shrinkage %	Thermal Shock Resistance	Cold Crushing Strength KN/m^2	Refractoriness ^{o}C
Onibode	2.60	28.40	87	4	30+	17.000	1760
Ara-Ekiti	1.84	18.0	75	8	26	14.000	1650
Ibamajo	1.76	16.0	78	4	30+	11.700	1630
Ijoko	2.60	22.0	88	6	28	19.000	1680
*Fireclay	1.90-2.30	15-25	25-90	7-10	20-30	15000 minimum	1500-1700

***Source: Omowumi[8]**

CONCLUSIONS

From the results of the investigation the following conclusions can be made:

(1) The fired bricks have good and smooth surface as the percentage of bagasse ash additions increased.
(2) The linear shrinkage and apparent porosity of the bricks decreased as the percentage of bagasse ash increased. This means that bagasse ash does not easily burn off or fused. This suggests an improved vitrification-taking place.
(3) The cold crushing strengths increased as the percentage of bagasse ash increases. This means that high strength bricks, can be made from these blend
(4) There is a remarkable improvement in the thermal shock resistance at 1300°C with percentage increase in bagasse ash to a level of 25 cycles at 25% addition. Since there was increased in the thermal shock at 1300°C at from 10% addition, it implies that bricks produce from these blends will be suitable for batch furnaces application.
(5) The work has found out that dense fire clay brick capable of possessing strength at operating temperature can be made from these blends. Since all the value obtained are within the recommended values for fire clay bricks.

REFERENCES

[1] S.B.Hassan; The Study of the Refractory Properties of Some Nigerian Clay Deposits, Masters Thesis, Department of Metallurgical Engineering, ABU Zaria, 23-40 **(1990)**.
[2] V.S.Aigbodion; An Investigation Of The Effect Of Ile-Oluji Clay On Some Refractory Properties Of Alkaleri Clay; Insights On Science And Technology, Afro-Euro Centre For Development Studies, Isbn: 978-84-612-8473-3, Printed In The Kingdom Of Spain, 21-29 **(2008)**.
[3] J.H.Chester; The Iron and Steel Institute, London, **4-13**, 295-315 **(1973)**.
[4] A.R.Chesti; Retice-Hall of India, New Delhi, **25-27**, 26-90 **(1986)**.
[5] V.S.Aigbodion, A.S.AbdulRahman, I.A.Madugu; Science and Engineering, **4(2)**, 135-142 **(2007)**.
[6] V.S.Aigbodion, S.B.Hassan, T.Ause, G.B.Nyior; Journal of Minerals & Materials Characterization & Engineering, **9(1)**, 67-77 **(2010)**.
[7] E.O.Akinbode; Indian Foundry Journal, 10-13 **(1996)**.
[8] Omuwomi; Nigerian Journal of Engineering Materials(NJME), **2(3)**, 34-40 **(2001)**.