Quest Journals
Journal of Research in Mechanical Engineering
Volume 2 ~ Issue 2 (2014) pp: 01-05
ISSN(Online) : 2321-8185
www.questjournals.org

Research Paper

Effects of Blending On Refractory Properties of Some Selected Local Clays in South Western Nigeria

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Received 06 March, 2014; **A**ccepted 07 June, 2014

***ABSTRACT*:-** Investigations were carried out on the effects of blending on the refractory properties of some selected local clays in the South Western Nigeria. The clays were collected from sites in Ado Ekiti, Ikere, Ilawe, Isan and Ire. The clay materials were crushed pulverized, sieved and their chemical compositions determined. The samples were moulded into cylindrical and cubic shapes and were allowed to dry in oven for seven days. The moulded samples were labeled A, B, C, D and E. Apparent porosity, apparent specific gravity, bulk density, linear shrinkage on firing, loss on ignition refractoriness, spalling resistance and compressive strength were determined. Results obtained show that samples C and E has a good thermal shock (spalling) resistance and can therefore be used for furnace lining while samples B and D are good for making of pots and plates.

KEYWORDS:- Blending, Clays, Mechanical Strength, Refractory, Properties.

I. INTRODUCTION

Clays are refractory materials that are mostly non metallic minerals which has enormous heat capacity, that can withstand high temperatures and pressure exerted on them such as thermal shock, impact, chemical attack and high load of elevated temperature (Abaa et. al, 1989). Omotoyinbo and Oluwole (2008) defined refractories as materials which have the ability to withstand high temperature without breaking or deforming. It is an unfortunate fact that despite vast clay deposits in Nigeria, the Country's metallurgical industries still depend on imported refractories to meet local consumption to meet local consumption as a result, a lot of hard earned foreign currencies arc spent in the process. Mohammed, (2009) reported in his work on refractory properties of termite hills under varied proportions of additives that over 80% of the total refractory materials are being consumed by the metallurgical industries for the construction and maintenance of furnaces. Kiln, reactors, vessels and boilers, while the remaining 20% are being used in the non-metallurgical industries as cement, glass and hardware.

Borode, et. al., (2000) revealed that around the end of the century, the steel industry in Nigeria would require about eighty thousand alumina bricks per year. In the independent studies of Omotoyinbo et al., (1997), and Borode et al., (2000), it was revealed that some clays deposits in Nigeria could be developed into good refractory materials for the lining of furnaces and other related metallurgical equipment with or without binder addition. Because of the anticipated improvement that can he given to local clays through blending this work is therefore aimed at investigating the effect of blending on the refractory properties of some selected local clays. To this end, clays at five locations from five towns in Ekiti State, in South Western Nigeria were chosen for studies.

II. MATERIALS AND METHOD

1.1.1 MATERIALS

Materials used were clays obtained from Ado, Ikere, Isan, Ire and Ilawe all in Ekiti state, in South Western Nigeria. Other facilities used include jaw crusher, oven/furnace, weighing balance, ball mill, sieve shaker, milling machine, plastic basin and sieve of 860 m mesh: obtained from Mineral Processing laboratory of the Department of Metallurgical and Materials Engineering Federal University of Technology, Akure, Ondo State. The chemical analysis of these materials was done at the Soil Analysis Laboratory of the Civil

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Engineering Department, Federal University of Technology, Akure, Ondo State, and the results are shown in Table 1.

Table 1: Chemical Composition of the Clays

SOURCE OF CLAY	CHEMICAL COMPOSITION OF THE CLAY SAMPLES (wt %)							
	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O
ILAWE	45.76	0.75	34.42	1.16	0.29	0.35	0.03	2.36
ADO	46.10	1.37	33.26	0.64	0.63	1.11	0.24	1.40
IKERE	44.93	0.06	38.31	1.49	0.07	1.13	0.05	1.90
ISAN	46.50	1.04	30.01	1.18	2.09	0.96	0.13	0.11
IRE	54.00	1.50	39.35	1.98	0.30	0.20	0.01	0.90

III. METHOD

The clay materials were crushed and pulverized by grinding using jaw crusher and ball mill to allow for particle size homogeneity. They were blended in five different proportions to obtain samples A, B, C, D and E (Table 2). Each proportion was soaked in a basin for five days and made into slurry through mixing. They were wet sieved with 860 m mesh. The sieved samples were moulded into cylindrical shapes using moulds of dimensions 4.5cm x 4.5cm x 5.0cm and oven-dried for seven days at a temperature range of 100 – 130^{0}C. The obtained products (i.e dried samples) were subjected to standard refractory tests. The tests performed were (a) apparent porosity, (b) apparent specific gravity, (c) bulk density, (d) linear shrinkage on firing, (e) Loss on ignition (L.O.I.), and (f) refractoriness. Others include spalling resistance and compressive strength tests.

Table 2: Proportion of blending of various samples (%)

Samples	Isan	Ado	Ikere	Ilawe	Ire	Total
A	90	5	-	5	-	100
B	-	90	-	5	5	100
C	5	-	5	-	90	100
D	5	5	-	90	-	100
E	-	5	90	-	5	100

IV. RESULTS AND DISCUSSION

1.2.1 RESULTS

The results of the test carried out on the blended samples are as presented in figures 1-7.

Figure 1: Apparent porosity (%) of the blended samples
Figure 2: Bulk Density (g/cm^3) of the blended samples
Figure 3: Linear shrinkage on firing (% loss in wt) of the blended samples
Figure 4: Loss on ignition (% loss in wt) of the blended samples
Figure 5: Temperature of the blended samples
Figure 6: Thermal shock resistance of the blended samples
Figure 7: Compressive strength of the blended samples

V. DISCUSSION

Result of the chemical Analysis of the clay samples (Table 1) showed that Isan clay is acidic because of the SiO_2 content. The acidity was found to reduce in the following order: Ire clay > Isan clay > Ado clay > Ilawe clay > Ikere clay. The Al_2O_3 contents of the various clays are comparable to the standard values given by Gil Christ (1977), and the values clays of other constituents were found to be within this normal range. The difference in the behaviour of the samples (Table 2) under the same condition is accounted for by the differences in percentage compositions of the constituents, this agrees with the work earlier carried out by Mohammed, (2009). He reported in his work on refractory properties of termite hills under varied proportions of additives that the behaviours of the samples under the same condition varied.

In this report porosity values of the samples were observed to vary. Omotoyinbo et al, (2008) gave factors that are known to affect porosity to include composition, size and shape of clay particles, others include ramming pressure, and reaction occurring on firing. According to Hassan, (2007) porosity determines the resistance of the material to penetration of molten slags, metal, and flue gases. The relatively low porosity values of samples B and D (Figure 1) as compared to samples C, A, E could be due to presence of low content of combustible materials in them. The presence of pores in clay affects the strength by reducing the crosssectional area expose to an applied load, hence samples B and D when used for furnace lining are expected to be able to support the weight of materials charged into the furnace better than sample A, C, and E. Also, because of decrease in number of pores created in them, they are capable of having good resistance to the penetration of molten slags, metal and flue gases when used as furnace lining.

The relative decrease in the pores of samples A, C and E was observed to come in order of the porosity value of samples C, E and A which are 25%, 23% and 16% respectively, the decrease may be accounted for by variation in the loss in ignition which has theses values 7, 6 and 5 respectively (Fig. 4). Therefore samples A, C and E can accommodate expansions that take place in it on heating.

Results of samples' bulk density are shown in Figure 2, the values varied between 1.26g/cm^3 to l.98g/cm3. This property has been shown to be important in the transportation or handling of refractory materials, and is also responsible for the over all weight coming upon the foundation of a refractory structure in a furnace. According to Omotoyinbo et al, (2008) some of the factors known to affect this properties include treatment during manufacturing, nature of the materials in the clay samples, and the proportion of the clay mixture with their size affected the bulk density. With the rather high values of samples' bulk density, handling and transportation of the sample may be costly.

Results of the samples linear shrinkage on firing are seen in Figure 3, variations in the samples percentage is within the range of 2.63% and 5.18%. The highest values of percentage linear shrinkage is obtained with samples B and D with values of 5.18% and 4.05% respectively. From the results it is generally observed that variations in the samples percentage shrinkage is within narrow range, the observation may be due to the samples' composition (particle size) and porosity. The obtained values depict that each of the blend if used, lining of low refractory furnace would perform optimally, as they are found to present good tolerance and thermal stability. Obikwelu (1987) had showed in his work on the viability of local clays for the manufacture of refractories for steel that the values of linear shrinkage is very important as the value affects sample's tolerance and posited that the higher the value, the greater the difficulty in having good tolerance.

Figure 4 shows the results of sample loss on ignition, the range is found to lie between 5.30% and 9.61%. The percentage of sample loss on ignition is found to increase in the order of samples A, E, C, B and D. This is an indication of increase in the amounts of combustible materials in the blends.

Values of the refractoriness of the samples are shown in Figure 5. Alumina content of clay determines its refractoriness (Hassan et al, 1994), and according to Mohammed (2007) high value of silica content and other particles such as Fe_20_3 contribute to low refractoriness. Therefore, in this study the relative increase in values of refractoriness of samples C and E may be due to the relative increase in the alumina contents of these samples. Hence, samples A, B and D were found to be stable up to temperature of 1,350^{0}C, above this range sign of melting was noticed, while for samples C and E, melting could not be established even beyond l470^{0}C and since the furnace used in this work is designed to operate at maximum temperature of 1600^{0}C, melting temperature of the two blends could not be determined. Hence, the observed stable up to 1470^{0}C.

Results of the samples thermal shock resistance is shown in Figure 6. The result showed that sample B has the least number of cycles i.e. 20 cycles while sample C and E were found to resist spalling up to 29 cycles. The property of a material to yield under stress without rupture is very significant in the materials resistance to spalling. The observed variations in the samples resistance to spalling according to Omotoyinbo et al, (2007) is influenced by particle size, coefficient of linear expansion, and thermal conductivity of the material. Hence, the observed improved thermal shock resistance of samples C and E over samples A, B and D may be attributed to their coarse particle size and low thermal coefficient of expansion.

From the results obtained in Figure 7 on compressive strength of the samples after firing up to temperature of 1250^{0}C showed that samples B and D have the highest strength value of 3.570 x 10KN/m^2, while samples A, C and E have values of 1.700 x 10KN/m^2, 2.182l0KN/m^2, and 2.261 KN/m^2 respectively. Variations in the values of the compressive strength is majorly due to variations in fineness of the particles, increase in number of the samples pores may also be responsible for the observed variation, Hence, samples B and D with least numbers of pores were found to exhibit better compressive strength properties, this observation agrees with that of Onyemaobi et al, (1995). He stated that increase of pores lower the compressive strength. Omotoyibo et al, (2007) has also attributed variation in material's compressive strength property to chemical composition difference such as high silica content and alkali metal presence which could result in glassy fussion during firing. Apart from the observed increase in compressive strength properties of samples B and a D, only marginal increase in the compressive strength of the other samples (A, C, and E) over each other was noticed. In general it was observed that variation in the compressive strength of the samples is moderate. This is attributable to the fact that the sizes of the grains of the samples are close.

VI. CONCLUSION

From the results of these tests, it can be concluded that samples C and E has a good thermal shock (spalling) resistance which has good recommendation for lining of furnace while samples B and Dare good for making of pots and plates. They have very good strength due to their grain size. It can also be concluded that grain size played a prominent role in affecting the general properties of the clay samples.

ACKNOWLEDGEMENT

The authors wish to acknowledge the Federal University of Technology, Akure and Ekiti State Technical College Ceramic Workshop in Ado Ekiti for the use as their laboratories.

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Table 3: Computed result of apparent porosity

Samples	Weight of fired sample (g)	Weight of specimen suspended in water (g)	Weight of soaked samples	Apparent porosity
A	180.00	77.00	200.00	16.26
B	162.00	83.00	165.00	3.66
C	127.00	51.00	152.00	24.75
D	191.00	80.00	194.00	2.63
E	139.00	63.00	162.00	23.23

Table 4: Computed result of bulk density

Samples	Weight of fired sample (g)	Weight of specimen suspended in water (g)	Weight of soaked samples	Bulk density g/cm^3
A	**180.00**	**77.00**	**200.00**	**1.46**
B	**162.00**	**83.00**	**165.00**	**1.98**
C	**127.00**	**51.00**	**152.00**	**1.26**
D	**191.00**	**80.00**	**194.00**	**1.68**
E	**139.00**	**63.00**	**162.00**	**1.40**

Table 5: Linear shrinkage on firing

Samples	Length before firing (cm)	Length after firing (cm)	Difference in weight	% Loss in weight
A	9.75	9.45	0.30	3.08
B	9.84	9.33	0.51	5.18
C	9.75	9.50	0.25	2.63
D	9.76	9.38	0.38	4.05
E	9.74	9.47	0.27	2.77

Table 6: Loss on ignition

Samples	Weight of firing	Weight of firing	Difference in weight	% Loss in weight
A	1.80	1.68	0.12	5.3
B	2.08	1.90	0.18	8.65
C	1.51	1.43	0.08	6.67
D	2.29	1.75	0.22	9.61
E	1.57	1.48	0.09	5.73

Table 7: Refractoriness

Samples	TEMPERATURE
A	1,350
B	1,350
C	1,470
D	1,350
E	1,470

Table 9: Thermal shock Resistance

Samples	Undergone no of cycles
A	22
B	20
C	29
D	23
E	29

Table 10: Compressive strength

Samples	Area (m^3)	Compressive Force (N)	Compressive Strength x $10kN/m^3$
A	0.007	11900.00	1.700
B	0.006	21420.00	3.570
C	0.006	13090.00	2.182
D	0.006	21420.00	3.570
E	0.006	13566.00	2.261