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Production of Refractory Binding Material for Cement Kiln *(pp. 44-49)*

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Abstract: This paper investigates the production of refractory binding material for lining bricks in the cement kiln using locally available materials. Titrimetric method was used to estimate the main constituents of imported refractory orylex mortar and local river sand. It was observed that silicon fire-clay, fire clay and high alumina refractory binder used in binding bricks at the calcining and safety zones of cement kiln have related constituents as the local river sand and clays. The local refractory mortar was produced by subjecting milled local river sand to heat with subsequent reduction of the sinter size. This is then mixed with prepared sodium silicate solution of various concentrations to give a locally produced composite binder. The product was then tested for stability in electric furnace at 1000^0C. The project thus highlighted some possibilities of production of local refractory binding material from locally available raw material.

Key words: safety zones, refractory binding, fire clay, lining bricks, kiln, cement.

1 INTRODUCTION

A variety of high performance refractory materials are employed in a number of industries including iron and: steel, non-ferrous metals, cement, glass, ceramics, petroleum and gas in Nigeria. A survey reveals that between 1980 and 1984, a total of two million tones of various types of refractory materials costing nearly N180 million were imported into Nigeria from Brazil (Eguakhide, 1987).

Researches have been done in Nigeria, exploring the possibility of local refractory bricks production. Nevertheless, due to the technological requirements and other associated problems involved in the production of high performance refractory bricks, they are yet to be produced locally. On the other hand, nothing has been done on the production of refractory binding materials. The local production of refractory binding materials has become necessary because of its increasing needs. It will also reduce the cost and quantity of imported refractory materials from across the Atlantic.

2 LITERATURE REVIEW

Refractory binding material is a synthetic polymeric composite used in fastening refractory bricks together and to the walls of process kiln or furnaces. Basically two types of binders

are used for the installation of the cement kiln refractory lining. The special mortar binder, used for fire clay as well as for magnesite bricks mostly applied in Europe (Shreve and Srink, 1984). This type of mortar is operationally reliable and is the most popular type for cement kilns. The binder is obtained by mixing the appropriate special mortar to consistency with concentrated alkali metal silicate solution. The second type which is the adhesive binder is a modified glue of a modified synthetic resin Epichlorhyrin (C_3H_sOCI) and Diphenyl propane ($(C_6H_5)_2C_3H_3$), whose adhesiveness exceeds the refractory's sterile strength. It is usually used in large diameter refractory kilns and so not yet popular in Nigeria as there are no very large kilns. Heat resistive concretes from orthophosphorous acid (H_3PO_4) or acid phosphates magnesium and chrome with different degree of substitution is widely known in Russia. The aggregates for this kind of concretes, depending on their place of use, can be aluminum silicate, magnesite chrome and lime magnesite matertals with fine granulometric content (Kuzmenkov, 1987). A study of the process dynamics of clinker production is essential for the construction of kiln refractory. Accordingly, the type of refractory binder used in kiln construction depends on various factors which include the fire temperature, atmospheric conditions, the reaction of the molten materials with the combustion gases and the refractories. The physico-chemical properties that are to be considered for the selection, specification and preparation of the raw materials for the production of refractory binders include the mechanical strength, refractoriness thermal sock, resistance to chemical attack, thermal expansion or stability of volume, thermal conductivity and resistance to abrasion. Some of the different refractories used in the cement kiln are silica- alumina used in the inlet, cemleg used at the calcining zone, high alumina bricks used usually at the safety zone, magnesia-chrome bricks and special magnesite bricks used at the transition and sintering zones of the kiln. It is suspected that the refractory binding mortar for the various zones of the kiln should be made of the same or liked materials with the bricks. The various types of kiln refractories are represented in Table 1.

Table 1: Composition of Cement Kiln Refractory Bricks

	Silcon fire clay	Fire clay	High alumina	Magnesite	Magnestic chrome	Chrome magnesite	Dolosite bricks
Al_2O_3	18-30	30-45	60-72	-	-	-	1-2
SiO_2	85	52-60	-	0.8-3.5	1-3.5	6	2-3
Cr_2O_3	-	-	-	-	6-20	15-35	-
CaO	-	-	-	0.8-3	1-3	2.5	48-50
MgO	-	-	-	92-96	55-80	25-55	36-40

Source: Ghosh (1983).

Careful observation reveals that AIO_3 and SiO_2 form the major raw material for producing refractory bricks and binding mortar for the calcining and cooling zones of the kiln, while magnesite is the major raw material (for their production (or the sintering zone). The raw material deposits (or the production of refractory binding materials are abundant in Nigeria.

The tested clays of various states and availability of many rivers and sea reveal this. The table below shows the results of some tested clay deposits.

Table 2: X-ray Fluorescence Results for Some Nigeria Fire Clays

Oxides, %	Ozzalla Deposite	Ibure Deposit	Irrua Depoist	Ewu Deposit
SiO_2	66.77	51.67	53.68	64.15
Al_2O_3	18.56	26.05	29.35	17.69
Fe_2O_3	4.06	3.89	2.48	4.17
TiO_2	1.51	1.74	2.06	1.28
MnO_2	0.03	0.04	0.03	0.05
MgO	0.16	0.64	0.23	0.21
CaO	0.03	0.21	0.03	0.10
K_2O	0.10	0.43	0.20	0.07
P_2O_5	0.05	0.07	0.06	0.03
LOI	9.16	15.21	12.01	11.84

Source: Ghosh (1983).

The purpose of calculating the composition of the raw mix in the production of binder is important for the determination of the quantitative proportions of the raw component that will give the product the desired chemical and mineralogical composition. The simplest method of calculation for solving blending problems is known as Alligation Alternate.

The method of technology of refractory binding materials consists of combining sodium silicate (Na_2SiO_2) solution with special mortar which is produce separately. At the present time there are more than forty varieties of commercial sodium silicate each with specific use. These are unique in that the ratio of their constituent parts, Na_2O and SiO_2 may be varied to obtain desired properties. The production of Na_2SiO_2 is by fusing sodium carbonate and silica (sand) in a furnace at about 400^0C. Ammonium method of manufacturing soda ash is the chief method now in commercial use, developed at the end of the 19th century by Solvay, a Belgium Engineer. The raw material for this process is limestone or chalk, common salt in saturated solution and ammonia. The chemical reaction which takes place in the soda ash-silica process is described by the equation

$$Na_2CO_3 + nSiO_2 \rightarrow Na_2O.nSiO_2 + CO_2 \qquad (1)$$

3 EXPERIMENTAL WORK AND RESULT

The experimental works undertaken in this project includes the titrimetric analysis of imported orylex mortar to serve as a guide in the selection and processing of suitable local raw materials for its local production; the chemical analysis of local river sand to examine its suitability as a basic raw material for the production of refractory mortar binder; the chemical production of local refractory mortar and the testing of the hypothesis to verify the efficiency of the locally produced binding material.

The result of the experimental determination of the constituents of imported refractory orylex mortar is presented in Table 3.

Table 3: Chemical Composition of Imported Refractory Orylex Mortar.

Oxides	LOI	SiO_2	CaO	MgO	Fe_2O_3	Al_2O_3	Rest	Total	SR	AR
Amount, %	3.94	92.35	0	0	0.47	0.07	2.54	100	78.93	1.49

SR-Silica Ratio

AR -Alumina Ratio

Table 4: Chemical Composition of Local River Sand

Oxides	LOI	SiO_2	CaO	MgO	Fe_2O_3	Al_2O_3	Rest	Total	SR	AR
Amount, %	0.16	84.15	0	0	0.39	0.75	14.55	100	73.82	1.92

The local refractory mortar was produced by milling a sample of river sand to about 15μm and then tested to be composed of about 84% SiO_2 as in table 4. An electric furnace at about 1440^0C was used for the transformation. The sinter product was then cooled and ground to about 10μm.

The testing of the hypothesis was performed by mixing the locally produced mortar to consistency with Na_2SiO_2 solution of 5 different concentrations. The binder was used to fasten two pieces of Cimleg refractory bricks together at flat surfaces and the different specimens were kept in electric furnace for over two hours. After gradual cooling the specimens were removed and observed for suitability.

4 DISCUSSION OF RESULT

From the experimental results obtained, the following salient points were made:- Literature survey reveals the raw material specification of imported orylex mortar to be 80-85% SiO_2. The chemical analysis of the product as seen in table3 shows the presence of 92.35% SiO_2 .This shows the predominance of SiO_2 in the orylex mortar which is a pointer to the type of raw material needed for its production. The analysis of the local river sand shows the presence of 84.15% SiO_2 which is within the literature value. Apart from the predominance of SiO_2 in the local sand, it also contain acid oxides like Al_2O_3 and Fe_2O_3 which are most often used in silicate technology. The chemical composition of the local river sand shows its suitability as a basic raw material for the production of refractory binding mortar. In this experimental production of local refractory mortar, only solid phase sintering occurred, since the furnace temperature did not get beyond 1440^0C. A distinction exists between sintering in the solid phase and sintering with a liquid phase participating. Solid phase sintering consists in filling the spaces inside the grain (pores). This occurs as a result of

increased mobility of the atoms in the crystal lattice at high temperatures. Simultaneously, the grains recrystalizes i. e. some of the crystals grow in size at the expense of others. The rate of solid phase sintering depends on the grain size and the presence of defect in the crystal lattice. The Alligation Alternate method used in solving blending problems allows the determination of the proportion of two raw material components to obtain a required composition. Raw material blending can be used to introduce necessary corrective

ingredients and mineralizers during production. The testing of the hypothesis reveals that the locally produced binder is efficient. The strength of a polycrystalline refractory fibre is highly dependent on its microstructure. Pores, defects, as well as crystalline size affect the microstructure and the properties (Brucke, Shurmans and Verhoest, 1984). In this experiment, the concentration that produced best result is 6.88 mol/dm^3 Na_2/SiO_2. Other concentrations of Na_2SiO_2 used are 3.44 mol/dm^3, 4.51 mol/dm^3, 6.05 mol/dm^3 and 7.05 mol/dm^3.

5 CONCLUSION

This project has shown the possibilities of production of local refractory binding material. The basic raw material and necessary corrective ingredients are locally abundantly available. River sand containing high percentage of silica is suitable for the production of refractory mortar. It possesses all the necessary properties required for producing refractory binding materials and subsequently, the following recommendations are made:-

1. The local refractory mortar can be produced by cement industries since already the raw mix for clinker production contains about 20% SiO_2.

3. The locally produced refractory mortar should be mixed during application with Na_2SiO_2 of correct concentration for effective binding.

4. The locally produced binder may be applied to fasten refractory bricks to process furnace other than cement kiln.

5. A study of the effects various mineralizers which can bring about the lowering of the molting temperature of the mix should be undertaken for economic purposes.

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