Study on the Analysis of Chromite Refractory Brick from Mwe Taung Chromite Ore

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ABSTRACT
This research paper is the preliminary study of testing the feasibility of chromite ore to produce refractory. Chromite ore was taken from Mwe Taung, in Chin State, Myanmar. Chromite ore contains iron oxide, alumina, magnesia, lime, chromic oxide and silica. The prepared chromite has been extensively used for high temperature metallurgical reactions. The chemical analysis of chromite ore was done to know the composition. Composition expresses the percentage of oxide component which can able to determine whether the refractory is acidic, basic or neutral. The chromite ore studied in this research is neutral refractory. The experiment of chromite refractory brick production was carried out first, the chromite powder are reduced to 50 mesh, 100 mesh and 200 mesh through sieving and then, mixed with magnesium chloride as binder, applied to 400 tons pressure, heated at drying temperature (200°C) for twenty four hours and at firing temperature (1580°C) for fifty two hours to produce chromite refractory brick. Analysis of locally available chromite refractory brick produced is tested. The standard properties such as cold crushing strength, apparent specific gravity, apparent porosity, bulk density and water absorption.

KEYWORDS: Chromite Ore, Chromite Refractory Brick, Porosity, Bulk Density, Cold Crushing Strength

INTRODUCTION

Refractory materials are chemical compounds that are used as structural materials forming insulation linings and as containment vessel in high temperature and corrosive environments in many industrial processes. In the design and construction of furnace and related apparatus refractory materials are used owing to their ability to withstand high temperatures without serious deterioration. Refractory may be expected to be relatively unaffected by high temperature under stress whether negligible or heavy, to resist mechanical abrasion at various temperature, to resist the instruction of molten metals, slags, or metallic vapors, as well as the action of superheated steam and hydrocarbons sulphurous oxide, chlorine, or other gases, and to withstand sudden temperature changes.

The use of chromium in refractories is important in metallurgical applications. The mineral chromite is the ore of chromium. A typical composition of a chromite suitable for refractory purpose is 38 to 48 % Cr_2O_3, 12 to 24% Al_2O_3, 14 to 24% Fe_2O_3, 14 to 18 % MgO, and less than 10% SiO_2.

The usage of chromite as a refractory is based on its high melting point of 2180 °C (3960ºF), moderate thermal expansion, neutral chemical behavior, and relatively high corrosion resistance. Chromite enhances thermal shock and slag resistance, volume stability and mechanical strength. Chrome-based refractories are typically used in cement kilns, secondary steel refining furnaces, foundry sands, glass melting furnaces and incinerators. In some cases alternative materials such as magnesium- aluminum spinels, spinel–bonded magnesite and high alumina refractories have replaced chrome-containing refractories.

The service behavior of refractories is determined largely by the skill and judgment exercised in matching refractory properties to specific service conditions. In particular it is essential to consider the various ways in which the process conditions are likely to cause failure. Accordingly the list of properties considered in selecting and using refractories include not only straight forward physical and chemical properties, such as density, specific heat, thermal conductivity and chemical analysis, but also other complex properties which relate primarily to the various mechanisms of failure.

Experimental Procedure
A. Test Method for Cold Crushing Strength of Refractory Bricks

The Amsler type Cold Crushing Strength Tester was used in this operation. Firstly, two test pieces of cube, each side of which was approximately 60 mm were cut from a sample brick. In the case of standard size brick, two test pieces with a size of a half piece was cut from the length way to make test pieces. In principle, the test pieces were capable of being pressed in right angle direction to the pressure direction while the sample brick was made, and prepared so that the

top and bottom faces were parallel and smooth. Both the upper surface and lower surface of sample were covered with a sheet with a thickness of 0.5 mm. A sample of chrome brick was placed on Amsler Type Crushing Strength tester. In testing, the pressure applied on the surface of the test piece was correctly placed in the center of the spherical seat. The pressure adding speed (10 -15 kg f/ cm² per second) was defined as standard, and the maximum load W (kg) was taken at the time when the test piece was crushed.

Calculation:
The mean value was calculated from two test pieces to obtain accurate results.

The cold crushing strength (Kg/cm²) was calculated by the following equation,

Cold Crushing Strength/ C.C.S (Kg/cm²) $= \frac{W}{a \times b}$, where

W = Maximum Load (Kg)

a ,b = lateral and side dimensions of the pressure adding surface
The results are shown below,
For 1st test piece, W = 18800 kg
   a = 60 mm
   b = 60 mm
For 2nd test piece, W = 21100 kg
   a = 60mm
   b = 60mm

Test 1, C.C.S $= \frac{W}{a \, x \, b} = \frac{18800 \, kg}{60mm \, x \, 60mm \, x \, \frac{1cm}{(10 \, mm)2}}$

$$= 522 \, Kg/cm\,2$$

Test 2, C.C.S $= \frac{W}{a \, x \, b} = \frac{21100 \, kg}{60 \, mm \, x \, 60 \, mm \, x \frac{1 \, cm2}{(10 \, mm)2}}$

$= 586 \, kg/ \, cm^2$

Therefore, the mean value is 554 kg/ cm²

B. Test Method for Apparent Porosity, Water Absorption, and Specific Gravity of Refractory Bricks under Vacuum Condition

A sample was cut off to a size of approximately 60 mm x 60 mm, and the corner portion was rounded as rounding prevents the chipping of the corner grains during the portion. Two test pieces were prepared from a sample brick.

The test piece was dried in a dryer at 105 – 120°C until the constant weight was obtained. It was weighed on a balance and called weight 1 (W_1). (Constant weight: Difference less than 1g in measured weight).

The test piece W_1 was put in the vacuum desiccator and covered (In the case of Small volume sample, it was convenient to use a beaker, of a suitable size). It is possible not to use the beaker if the sample is big.

On the contact surface of the cover vacuum grease was applied for air tightness. As shown in Fig (1), the cock for oil pouring was closed and the cock of manometer was opened, and operation of the vacuum pump was started. Then, suck for 15 minutes under the vacuum of 2 Kpa (15 mmHg) or under, then closed the cock of manometer and injected the oil by opening the cock for oil pouring gently after the air in fine cavities had been eliminated completely. In this case, inject the oil until the samples were socked completely, after

that closed the cock for oil pouring and opened the cock of manometer. Turned off the vacuum pump and opened the cock gently to introduce the air gradually.

Next, the desiccator was returned to the atmospheric pressure. If the opening of the cock was delayed too much, the oil in the vacuum, pump was sucked up and damaged the manometer. The cock of manometer was closed, gently after the system was returned to the atmospheric pressure. Then, the samples were left in the oil for minimum 30 minutes under the atmospheric pressure. Opening and closing of the manometer cock must be carefully performed while paying attention to the mercurial column, because the mercurial column is easily damaged.

1. Sample
2. Beaker
3. Vacuum Desiccator
4. Cover of Desiccator
5. Contact Portion of Desiccator Cover
6. Pressure Resistant Rubber Tube
7. Cock of Manometer
8. Scale of Manometer
9. Vacuum Pump
10. Cock for Oil Pouring
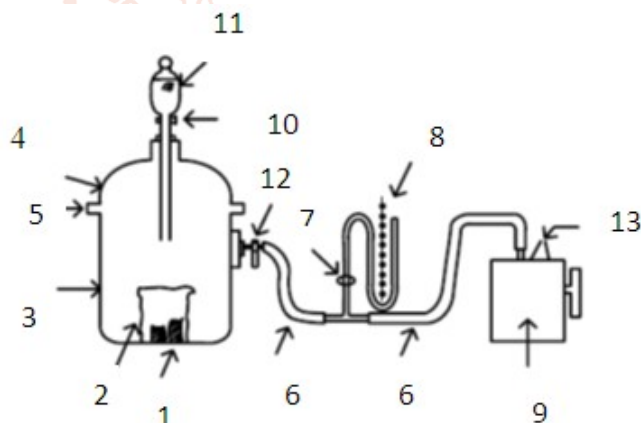11. Oil(Kerosene)
12. Cock
13. Exhausting Port

Figure1. Vacuum Desiccator with Oil Pouring System

The test piece for which the oil saturation had been completed was hung in oil with a thin wire or a wire basket, weighed and called weight 2 (W_2).

The test piece W_2 was measured. It was taken out of oil and the oil on the surface was adequately and quickly wiped out, and then it was put on the weighing plate of the balance, and the weight was measured and called weight 3 (W_3).
Calculation

The apparent porosity was calculated by the following equation, and rounded to one decimal place in accordance with JIS Z 8401.

Apparent porosity (%) $= \frac{W3-W1}{W3-W2} \, x \, 100$

The water absorption was calculated by the following equation and rounded to one decimal place in accordance with JIS Z 8401.

Water absorption (%) $= \frac{W3-W1}{W1} \, x \, 100 \, \div \, S$

The apparent specific gravity was calculated by the following equation and rounded to two decimals places in accordance with JIS Z 8401.

Apparent Specific Gravity = $\frac{W1}{W1-W2}$ x S

The bulk specific gravity was calculated by the following equation, and rounded to two decimals places in accordance with JIS Z 8401.

Bulk density = $\frac{W1}{W3-W2}$ x S

Where, S = gravity of kerosene
W_1 = mass of dried sample
W_2 = mass in water of sample saturated with water
W_3 = mass of sample saturated with water

The gravity of oil was measured with a specific gravity meter at each time. If a specific gravity meter was not available, a pycnometer was used after measuring its inner volume using water.

For 1st test piece, W1 = 199.7g
W2 = 161.5 g
W3 = 212 g
S = 0.78

Apparent porosity (%) = $\frac{W3-W1}{W3-W2}$ x 100

= $\frac{212-199.7}{212-161.5}$ x $100 = 24.36\%$

Water absorption (%) = $\frac{W3-W1}{W1}$ x 100 $\div$ S

= $\frac{212-199.7}{199.7}$ x 100 $\div$ $0.78 = 7.89\%$

Apparent Specific Gravity = $\frac{W1}{W1-W2}$ x S

= $\frac{199.7}{199.7-161.5}$ x $0.78 = 4.08$

Bulk Density (g / cm³) = $\frac{W1}{W3-W2}$ x S

= $\frac{199.7}{212-1\ \ .5}$ $x 0.78 = 3.08 g/cm3$

For 2nd test piece
W_1 = 202.8 g
W_2 = 164
W_3 = 215.2 g

Apparent porosity (%) = $\frac{W3-W1}{W3-W2}$ x 100

= $\frac{215.2-202.8}{215.2-164}$ x $100 = 24.22\%$

Water absorption (%) = $\frac{W3-W1}{W1}$ x 100 $\div$ S

= $\frac{215.2-202.8}{202.8}$ x 100 $\div$ $0.78 = 7.84\%$

Apparent Specific Gravity = $\frac{W1}{W1-W2}$ x S

= $\frac{202.8}{202.8-164}$ x $0.78 = 4.08$

Bulk Density (g/ cm³) = $\frac{W1}{W3-W2}$ x S

= $\frac{202.8}{215.2-164}$ $x 0.78 = 3.08 g/cm3$

Apparent porosity, water absorption, apparent specific gravity, and the bulk density of chrome brick are 24.29 %, 7.87%, 4.08 and 3.09 g/cm³ respectively.

C. Test Method for Refractoriness of Refractory Bricks and Mortar
A metal mold for forming the test cone having the shape and dimensions shown in fig (2) was used.

Where,
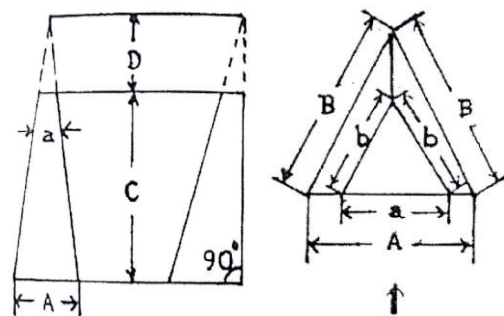A= 8.5mm, B=8.0mm, C=30.mm, D=11.5mm,
a=3mm, b=2.5mm

Figure2. Shape and Dimension of the Cone

To make the metal cone, the equal ratio of china clay and pure alumina powder was mixed with suitable amount of water and was put in the crucible. A sheet of thin card board was laid between the crucible and the base material. The purpose was to prevent the base material from sticking to the crucible. The base was allowed to dry at $110 ℃$ for 12 hours before testing. The crucible can test only four cones at one time. Therefore, the cones mixed with different binders were tested and compared with standard seger cone.

Several standard seger cones whose grade number of refractoriness equivalent and approximated to that of the test cone was selected and placed them near the test cone. The test cone and the standard seger cones (SK 35) were stood by embedding their lowers ends approximately 4mm deep in the stand as shown in fig (3), with one face of each cone (the marked face of the standard seger cone and the corresponding face of the test cone) was inclined by $80°$ from the horizontal surface of the stand.
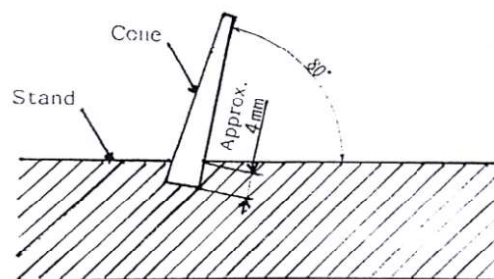

Figure3.Stand and Cone

The base was thoroughly dried before testing. Then, the crucible was placed on the crucible table of the kiln. A pressure regulator was attached to the propane gas container, and it was connected to the rubber hose which lead to the burners. A pressure regulator was attached to the oxygen cylinder and it was connected to the rubber hose which lead to the burners.

Results and Discussions

In Myanmar, a large number of naturally occurring raw materials have been found for the production of refractory materials. Among them, chromite ore was selected for this study. The raw material chromite ore was taken from Mwe Taung Area, in Chin State. To test the feasibility of the use of local chromite as refractory tests such as chemical analysis and refractoriness were firstly carried out. The test results are given below and discussed compared with the typical composition of chromite refractories.

Chemical Composition

The chemical composition of chromite ore in Mwe Taung and standard composition of chromite ore are shown in following table (1).

Table1. Typical Composition of Chromite Ore and Mwe Taung Chromite Ore

Minerals	Standard Compostion	Mwe Taung
Chromic Oxide	30 to 50%	45.44%
Iron oxide	12 to 16%	14.5%
Silica	3 to 6%	2.7%
Alumina	13 to 30%	20.57%
Magnesia	14 to 20%	16.4%
Lime	up to 1%	0.37%

By comparing these two compositions, it is obvious that the chemical composition of the local chromite ore is within the range of the standard composition. And so, it can be used for refractories.

A. Physical properties of chromite brick

The standard properties are- apparent specific gravity, apparent porosity, bulk density and water absorption.

The apparent specific gravity of chromite brick was 4.08 and the standard was 3.8 to 4.0. The porosity of chromite brick is about 24.29 percent and the standard is 14 percent. Therefore, the apparent porosity of chromite brick is more than the standard, this is because of non-uniform size distribution and inhomogeneity. The bulk density of chromite refractory brick is $3.09 g/cm^3$. The increase in the bulk density of a given refractory increases the strength, volume stability, heat capacity, resistance to slag penetration and generally resistance to structural spalling or spalling resulting from vitrification caused by fluxing with dusts and slags. The water absorption of chromite brick is 7.8%. The standard value is a bout 7 (unit).

B. Refractoriness

The result showed that the chromite refractory brick could stand at least 1800°C, at that temperature the brick was not yet fused. The standard temperature of chromite brick has between 1700°C to 1900°C. The refractoriness value shows the temperature at which the refractory material becomes soft and deformed. By comparing the sample brick cone with the standard cone, the refractoriness value of sample is nearly the same with that of the standard seger cone.

C. Mechanical properties of chromite brick

The result of cold crushing strength has $554 kg/cm^2$ and the standard has $400 kg/cm^2$. The cold crushing strength doesn't show the strength at high temperatures. It shows the strength at room temperature. But the cold crushing strength shows the degree of sintering. The good sintering means good physical properties.

Conclusion

In this research, the chemical composition of the local chromite ore is within the range of the standard composition. According to the pyrometric cone equivalent test, it has been found that chromite obtained by burning at 1800 C for 30 minutes, has high refractoriness. The cold crushing strength, apparent specific gravity, apparent porosity, bulk density, water absorption of the refractory brick are $554 kg/cm^2$, 4.08, 24.29 percent, $3.09 g/cm^3$, 7.87 percent and refractoriness could stand 1800° C.

In Myanmar, the chromite refractory bricks produced from this research paper can readily be used in furnaces, melting and works related with iron and steel production. Chromite refractory bricks are cheaper than chrome-magnesia brick and used for the same purpose as chrome-magnesia brick.

References

[1] Kenichi Sakurai, Refractories, Nagoya International Training Center Japan, International Cooperation Agency.

[2] Searle, Alfred B, 1940, Refractory Materials: The Manufacture and Uses

[3] Norton, F. H." Refractories"-,3rd ed., Mc Graw-Hill Book Company, New York, 1949.

[4] Felix Singer, Sonia S.Singe.,″Industrial Ceramics"

[5] Vogel, Arthur I, A Text Book of Quantitative Inorganic Analysis Including Elementary Instrumental Analysis.