Evaluation of the Chromite Refractory Lining Condition used in Induction Furnace

Waing Waing Kay Khine Oo* Shwe Wut Hmon Aye**
*Department of Metallurgical Engineering and Materials Science, West Yangon Technological University
Hlaing Thar Yar Township, Yangon Region, Myanamar
*waingkaykhine@gmail.com
**Department of Metallurgical Engineering and Materials Science, West Yangon Technological University
Hlaing Thar Yar Township, Yangon Region, Myanamar
**hmon152@gmail.com

DOI: 10.29322/IJSRP.9.08.2019.p92144
http://dx.doi.org/10.29322/IJSRP.9.08.2019.p92144

Abstract- Refractories refer to the heat resistant material and are widely used as the internal linings of furnaces, kilns, reactors and other vessels in the metallurgy industry. According to the chemical compositions, chromite is one of the neutral refractory. In this work, the chromite ore from Mwetaung area was used as raw material. Firstly, the chemical compositions and refractoriness were measured. The experimental works for chromite refractory materials for use in lining of induction furnace was carried out. To study the use of chromite raw material as induction furnace lining, five different sizes of chromite were mixed. Boric acid was used as binder. Cast iron and aluminium alloys were used as materials for melting. The lining was tested for a total of only (14) hours and (4) heat. After each test, the condition of the lining was studied and it was observed that no severe damage or erosion of the lining took place.

Keywords – chromite ore, chromite refractory lining, induction furnace, chemical compositions, refractoriness.

I. Introduction

Nowadays, induction furnaces are widely used in metallurgical industries because they can be used in a variety of ways. Induction furnace capacities range from less than one kilogram to one hundred tonnes. They can be used to melt cast iron, mild steel and various alloy steels. Two types of induction furnace are core type induction furnace and coreless type induction furnace. From this, the coreless type induction furnace is mostly used because they can be started on cold metal, they can be used for a bath-type operation and they provide uniform temperature control with localized overheating. The induction furnace body consists of four main parts such as furnace casing, induction coil, refractory lining and gear housing.[4]

Refractory lining is the protective layer inside the furnace or kiln that withstand high temperature applications as a form of insulation. The most important refractory properties are chemical analysis, structure and phase constitution, fusion and softening temperatures and thermal conductivity. The selection of refractory lining materials is closely related to the different types of slags such as basicity and acidity_ namely acid, basic and neutral. The main raw materials used as high silica, quartz and fireclay are acid refractories. They can used where slag and atmosphere are acidic condition. Magnesite and dolomite, chrome- magnesite and magnesite- chrome are basic refractories and they can be used in basic condition of slag atmosphere. Chrome and high alumina are neutral lrefractories and chemically stable to both acids and basic slags condition.[1]

In this work, the raw materials was obtained from Mwetaung area, Chin State. First of all, the chemical compositions are measured to know the content of chromium oxide. The typical content of Cr_2O_3 should be contained minimum amount of 30% for refractory purposes.

Secondly, the fusion and softening temperatures were measured because the refractory material that withstand the high temperature at which it is to be used. After that, the chromite refractory was used as in an induction furnace and condition of the lining was investigated.

The major goals of this study is to evaluate the characteristics and properties of Mwetaung chromite ore whether it can be used as refractory material or not. So, it will be tested as refractory lining and analyzed it behavior.

II. Experimental Procedure

A. Chemical Analysis

The chemical composition of Mwetaung area was determined by wet analysis method.

B. Fusion and Softening Temperatures

By using the Pyrometric Cone Equivalent (PCE) method, the fusion and softening temperatures of chromite ore were examined.

In this testing, the standard Seger cones were manufactured by the Japan Seger Cone Assciation. The prepared chromite cones mixed with different binders such as boric acid, sodium silicate and magnesium chloride were tested with three standard Segre cone (#35, #36, #37) for three times.

C. Using Lining Materials in an Induction Furnace

The raw chromite from Mwetaung area,Chin State was used for testing as lining in induction furnace.

D. Preparation of Chromite

This step included cleaning,drying, washing, grinding and sieving.

1). Cleaning

The raw ore chromite contained various impurities such as dust, insects and soil particles. So, the material was cleaned by washing with water at least two times and then dried naturally.

2). Crushing and grinding

The process of crushing and grinding can differ according to the different sources. The general size of the raw material was in the range between 20 mesh sizes to 1 inch cube. Five different sizes of materials are required for this experiment and so the different milling machines as shown in Figure 1 are used. The gyratory crusher was used to crush 3/2″ size to under 1/2″ size. To obtain under 5 mesh size, jaw crusher was used. By using pulverizer, powder particles were obtained. Ball mill was used to grind 5 mesh size to different under sizes to powder.

(a) Gyratory Crusher

(b) Jaw Crusher

(c) Ball Mill

(d) Pulverizer

Figure.1. Different Types of Milling Machines

3).Screening

The required sizes of material are

a) + 8 mesh size
b) -8 to +28 mesh size
c) -28 to +65 mesh size
d) -65 to +150 mesh size
e) -150 mesh size.

To obtain the above sizes, the crushed and ground particles were screened by using different types of sieve number. The sieve shaker which contains different types of sieves was shown in Figure 2.

Figure 2. Sieve Shaker

D. Induction Furnace Lining

As shown in Figure 3, test lining of local chromite refractory material in 0.15ton induction furnace was carried out. The former shown in Figure 4 which was needed for lining preparation was made of mild steel sheet and it was 2mm thickness. The dimension of the former is shown in Figure 5. Vent holes which had about 3mm diameters were made around the former sidewall for the escape of moisture.

The weight (kg) and ratio used for lining preparation is shown as Table 1. Boric acid was used as binder. The total weight of 150kg was required for lining preparation.

Figure 3. 0.15 ton Induction Furnace

The various ratios of raw material and boric acid were thoroughly mixed in concrete mixer as shown in Figure 6. for about 1 hour. Firstly, the cooling coil was inspected to check if water leakage took place or not.

The sealing of inductor was also checked and the diameter of coil was leveled out with a coil grout. After that the coil was set up into the furnace as shown in Figure 7. Before ramming, the asbestos cloth was covered as an insulating layer around the surface of the coil as shown in Figure 8. And then, the asbestos sheet was also covered on that layer in order to protect the coil as shown in Figure 9. After that, the inner height of the furnace was measured.

Figure 4. The Former

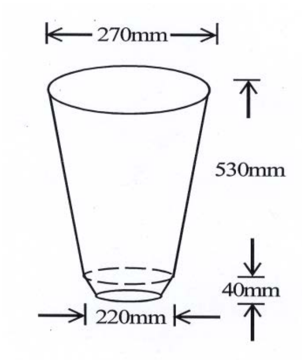

Figure 5. Dimension of the Former.

Table 1. Mesh (size) Number, Percentage and Weight of Refractory Material and Boric acid Used for 0.05 Ton Induction Furnace Lining

No	Material	Size	Percentage	Weight (kg)
1.	Chromite	+ 8 mesh	11.08	16.62
		-8 to +28 mesh	35.48	53.22
		-28 to +65 mesh	18.73	28
		-65 to +150 mesh	13.06	20
		- 150 mesh	21.65	33
2.	Boric acid		1.5	2.2
	Total			153.04

vFigure 6. The Concrete Mixer

Figure 7. Setting up the Coil

Figure 8. Covering by Asbestos Cloth

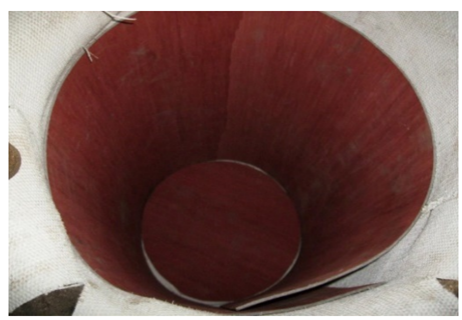

Figure 9. Covered with Asbestos Sheet

Firstly, the bottom of the furnace was rammed. The mixture was poured into the bottom about 240 mm thick and rammed with appropriate rammers and vibrator to get the thickness of 120 mm. And then, the mixture was again filled about 240 mm thick and rammed to get the total thickness of 240 mm.

The former was firmly seated on the bottom surface in the furnace as shown in Figure 10. Any voids between the former and its base can cause cracks from insufficient support. And so, a substantial weight of scrap was placed into the former to prevent shifting during ramming.

The prepared mixture was rammed layer by layer using the same tools for the sidewall. To avoid lamination, the side by side layer was loosened slightly. The workers changed their positions alternatively around the former while they were ramming.

The lining was rammed to the level of the topmost turn of the inductor. The capping material (refractory clay, chromite and silicate) was not excessively wet to avoid excessive shrinkage during curing. After that the lining was dried. When the lining was ready for use, some iron blocks were appeared in the iron blocks and the heat developed was transferred to the adjacent layer of the lining as shown in Figure 11.

Figure 10. Settlement of the Former

The power should be applied slowly to gently warm up the chamber to avoid cracking of the lining. The preheating temperature cycle was holding at 200°C for 2hr, keeping between 200°C to 600°C for 3 hr, 600°C to 900°C for 2hr, 900°C to1100°C for 2hr 1100°C to 1350°C for 1hr and temperature 1350°C for keeping time.

This process lasted for about 10hrs.If the power was applied too rapidly, uneven heating of the former could result in potentially catastrophic failures such as thermal shock and hazardous steam explosions. After preheating, the furnace was charged with some blocks of cast iron and melting operation was started.

Figure 11. Preheating the Furnace

Figure 12. Pouring into the Ladle

After getting that temperature, all the blocks were melted down. Then the molten cast iron was poured into the ladle as shown in Figure 12. From this, the molten cast iron was poured into the mold. After that, the lining was cleaned of remaining metal and slag and the condition of the lining was inspected visually.

III. Results And Discussions

A.Chemical Compositions

For the use of refractory purposes such as furnace lining, the chromite ore obtained from Mwetaung area was firstly determined the chemical compositions. The following table 2 was shown the test results and discussed compared with the typical compositions.

Table.2 Comparison between typical and Mwetaung chromite ore compositions

No.		Typical Compositons	Mwetaung Chromite Ore Compositions
1	Chromic Oxide	30 to 50 %	49.98%
2	Iron Oxide	12 to 16%	15.7%
3	Silica	3 to 6 %	4.68%
4	Alumina	13 to 30%	12.14%
5	Magnesia	14 to 20%	15.26%
6	Lime	Up to 1%	ND

By comparing these two results, it can be seen that the Mwetaung chromite ore is within the range the of typical compositions. For this reason, it can be used as the refractory material.

B. Fusion and Softening Temperatures

Following the Pyrometric Cone Equivalent (PCE) test results, the prepared chromite cones did not soften or fusion up to 1820°C. It can also be seen that the different binders could not affected in refractoriness. For this, the Mwetaung chromite ore has a fusion point of over 1825°C and the three different binders can be used.

C. Refractory Lining Condition

The chromite ore was tested as refractory lining in 0.15ton induction furnace.The lining condition after melting is discussed below.

Before the operation started, the lining thickness of side wall and bottom were measured. The lining thickness of sidewall was 130mm and the bottom was 240 mm, respectively.

For the first heat, cast iron was melted. The temperature recorded was 1350°C. The melting time was taken about 4hrs. After melting, the lining was cleaned of remaining metal and slag and inspected visually. After melting condition, the lining thickness of side wall and bottom were measured again and compared to the original dimensions. By comparing these two datas, it was observed that there was no difference in the lining thickness.

ISSN 2250-3153

For the second and third heats, aluminum alloys were melted. The temperature recorded was 700°C. The melting time was 30 minutes for each melting. After melting, the lining was cleaned and inspected visually. The lining condition after third time heating is shown in Figure 13.

Although the lining had been used for three melts, no change in the lining thickness was observed. It can be noted that the erosion of the lining had not occurred. But small cracks which were formed at the upper region of the side wall were detected. This was occurred because the molten cast iron was not reached and good sintering condition was not obtained. performance of chromite ore is mentioned in Table 3.

Figure 13. Lining Condition after Third Time Melting

Table 3. Performance of Chromite Ore

No.	Melted metal	Time (hr)	Condition of Lining	Remark
1.	Cast Iron	10	–	Preheating time
2.	Cast Iron	4	No Change in lining thickness	Melting
3.	Aluminum alloy	0.5	No change in lining thickness during short time melting	Melting
4.	Aluminum alloy	0.5	No damage	Melting
	Total	15		

It can be seen from the above table that the use of Mwetaung chromite ore as a refractory lining had tested for total of only (14) hours and (4) heats_ two for cast iron and two for aluminum alloy. After each test, the condition of the lining was studied and it was observed that no damage or erosion of the lining took place.

The number of tests that could be made depended on the restrictions and limitations of the factory such as furnace condition, necessary equipments, cost, time, labors and power supply. Therefore, the obtained results were discussed on the basis of melting on 14 hours of total melting time.

IV. Conclusion

In this study, the raw materials Mwetaung chromite ore can be used as the refractory material according to the test results. The chemical composition of Mwetaung chromite was within the range of standard compositions. According to the PCE test results, it does not soften or fused up to 1820°C.Because of limited testing facilities, some experiments could not be carried out. For testing the lining, fixed size distribution ratio and one type of binder, sodium silicate was used. In this study, locally The available metal scraps were charged during melting. If possible, the known chemical analysis of metal should be charged. According to the type of slag produced, the acid or basic melting practice can be chosen. In this tests, chromite refractory lining was tested for a total of only (14) hours and (4) heats. The number of tests that could be made depended on the restrictions and limitations of the factory. If possible, many tests should be carried out. However, various possible attempts were made to test the feasibility of chromite refractory lining.

According to the results obtained from both determination of properties and test works, Mwetaung chromite ore can be used as refractory lining material for induction furnace.

References

[1] Alfred B. Searle.1940, Refractory Materials: Their Manufacture and Uses.
[2]Allen M.Alper, Refractory Materials, A Series of Monographs High Temperature Oxides, Volume 5-1 (Part I)
[3]D.Turner.1934, Special Refractories for Metallurgical Research t High Temperatures, Trans. Ceramic Soc., 33.
[4]Hubble, D.H. 2000, Steel Plant Refractories, The Making, Shaping and Treating of Steel.
[5] Kenich Sakurai. Refractories, Nagoya International Training Center Japan International Cooperation Agency
[6] Norton, F.H. 1949, Refractories, 3rd ed., Mc Graw-Hill Book Company, New York.
[7]Richard W.Heine, 2nd ed. 1995, Principles of Metal Casting.

AUTHORS

First Author –Waing Waing Kay Khine Oo, Professor, West Yangon Technological University, waingkaykhine@gmail.com.
Second Author – Shwe Wut Hmon Aye, Professor&Head, West Yangon Technological University, hmon152@gmail.com.