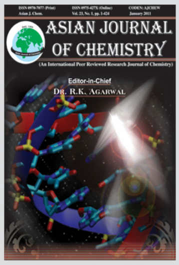
Asian Journal of Chemistry; Vol. 23, No. 10 (2011), 4557-4559

ASIAN JOURNAL OF CHEMISTRY

www.asianjournalofchemistry.co.in



Iron Recycling of Slag for E.A.F Steelmaking by Solid Carbon

M. KHOSHKI[1,*], M.H. GOLMAKANI[1] and M. MOMEN HERAVI[2]

[1]Department of Material Science and Technology, Mashhad Branch, Islamic Azad University, Mashhad, Iran
[2]Department of Chemistry, Mashhad Branch, Islamic Azad University, Mashhad, Iran

*Corresponding author: E-mail: mehdi_koshki@yahoo.com

(*Received*: 21 December 2010; *Accepted*: 27 June 2011) AJC-10097

Steelmaking slag from refining process both in oxygen converter and in electric arc furnaces contain a high portion of refined metallic iron-raw material. One of the most important applications for blast furnace and steelmaking slag is in cement production industry but high percent of iron-oxide in steelmaking slag can be useless for cement quality and also can wear the cement mills. Therefore, only demetallized slag could be useful and effective in cement factories. For this reason the first and very important process of steelmaking slag treatment is to divide the slag into two parts: a metallic one and a demetallized steelmaking slag. In this research, reports experimental studies on reduction of iron-oxide from a ternary FeO-SiO_2-CaO slag with solid carbon. In this process, E.A.F slag with some supplements as same coke powder and flux were mixed and fused in graphite crucible. The results indicate that FeO recycling by solid carbon is completely successfully and at least 60 % has been reduced.

Key Words: E.A.F, Slag, Demetallized slag, Reduction, Solid carbon, Blast furnace.

INTRODUCTION

Maintaining a predictable and consistent foamy slag for every heat has eluded many steel makers for a long time of ten times, adequate slag foaming occurs at the beginning of process and then decreases toward the end of the heat. Affinity and attention to decrease the melting time and therefore, increases the oxygen consumption in each melt has forced many steel makers to melt to a generic low carbon heat for every grade of steel, regardless of final carbon specifications. The amount of FeO generated obviously will depend on the amount of oxygen and carbon content. Unfortunately because of high oxygen consumption and low carbon injection, FeO content in slag has increased and nowadays FeO amount is a high portion (35-40 % wt) of electric arc furnace (EAF) slag.

Many institutions and societies appeared with the main aim to support the use of full production of both iron making and steel making slags. Multistep process of crushing, grinding and electromagnetic separation is utilized for this purpose. Very important way of utilization of demetallized slag is its recycling into steel making unit charge or other industries as same cement industry. However, the effects of temperature, FeO concentration and slag basicity will be very important in this issue.

In this paper some remarks on ways of iron making and steel making slags utilization are presented. Of course paragraphs related to steel making slags are restricted to slags from electric arc furnace process.The slags from other steel making process, as tundish of continuous caster or ladle furnace process are not including in this paper.

Blast furnace slag: Blast furnace slag is fully utilized. The slag is composed of gaunge minerals from iron bearing materials, slag forming addition and coke ash.

All structural components of blast furnace slag can be sorted in three general groups[1,2]: (1) Pyroxenes MeO × SiO_2; (2) Olivine's 2MeO × SiO_2; (3) Group of gelignite and melilite mMeO × nAl_2O_3 $pSiO_2$.

For treatment and utilization of blast furnace slag its chemical composition and mineralogical structure are decisive. The most important points are: character of major mineralogical components, crystallization rate, dimensions and forms of crystals, special distribution of crystalline and glassy phases.

According to these points methods of blast furnace slag treatment can be subdivided into fallow groups[3]: slag pit process, slag granulation process, pelletized slag, granulated blast furnace slag sand, technical ceramics

Steel making slags: Steel making slags from refining processes both in oxygen converter and in electric arc furnace contain a high portion of refined metallic iron-raw steel.

The first and very important process of steel making slag treatment is to divide the slag into two parts: (a) metallic one (steel scrap) and a de-metallized steel making slag.

For first item, multistep process of crushing, grinding and electromagnetic separation is utilized for this purpose. De-metallized part of steel making slag is utilized in civil engineering, in roads, dams, moles *etc*.

It is used mainly for stabilization of lower parts of soil because of high specific density of steel making slag. Applications in cement production industry and in treatment of acidic soils are also well-known. Of course very important way of utilization of steel making slag is its recycling into blast furnace or steel making unit charge.

Fundamentals: The overall reaction between carbon and iron oxide in slag can be expressed by eqn. (1):

$$FeO \text{ in slag} + C(s) = Fe(s) + CO(g) \quad (1)$$

where C(s) indicates a solid carbon such as coke or coal char in slag. In the steady state, the reaction proceeded with the gaseous intermediates between carbon and slag. This reaction meant that the overall reaction is a combination of the fallowing sequential reactions at different interfaces [4,5]. (1) Mass transfer of FeO to gas/slag interface from the bulk. (2) Chemical reaction at the gas/slag interface. (3) Diffusion of gaseous species in the gas film around the carbon. (4) Chemical reaction at the gas/slag interface.

EXPERIMENTAL

The slag used in the present study was produced by Mobarakeh Steel Company (MSCO). The chemical specification especially, FeO portion in the present study was confirmed by X-ray diffraction and chemical analyzers.

Induction furnace (model: inductoterm) is used for fusing the component in this process. The chemical specification in the present study was confirmed by X-ray fluorescence and chemical analyze technique. The recycle iron is analyzed by quantometer (model : spectromaxx)

For this project two different methods were compared together. The only different between these two methods was in the amount of silicon oxide (SiO_2). List of raw materials has mentioned in Table-1. 10 kg slag was mixed by 600 g coke powder (mesh size 30), 1000 g silicone oxide and 100 g Frugen H6 as flux and metal protection. Crucible was preheat in 150-200 ºC in the furnace, time of preheating was 5 min and power for this issue was 15 KW.

TABLE-1
RAW MATERIAL FOR TEST METHOD 1 AND 2

Raw materials	Slag (kg)	Coke (g)	Flux(g)	SiO_2 (g)
Test 1	10	600	100	1000
Test 2	10	600	100	50

Weight amounts of these constituents were mixed and fused at 1500 ºC in an graphite crucible in induction furnaces (power: 100 kw, frequency: 800 hz, voltage: 800 volt) that the power increase toward the end of the heat (power: 200 kw, voltage 1200 volt).

RESULTS AND DISCUSSION

Table-2 presents the chemical composition of steel making slag of Mobarakeh Steel Company. Table-3 presents data on reduction of FeO by solid carbon in induction furnaces for each test method. It also shows, for the sake of comparison primary data from electric arc furnaces. The portion of FeO in primary slag (Table-2) is more than 35 % and after reduction (test one in Table-3) this amount has decreased to less than 8 %. Of course slag basicity (CaO/SiO_2) was decreased to 1, which showed that slag is approximately acidic or natural and this issue will be increase the refractory consumption and other parameter such as energy consumption and yield, *etc*.

The data in Fig. 1.[6] is important as it defines the minimum amount of MgO required in slag to be compatible with basic refractoriness for a specific basicity ratio.

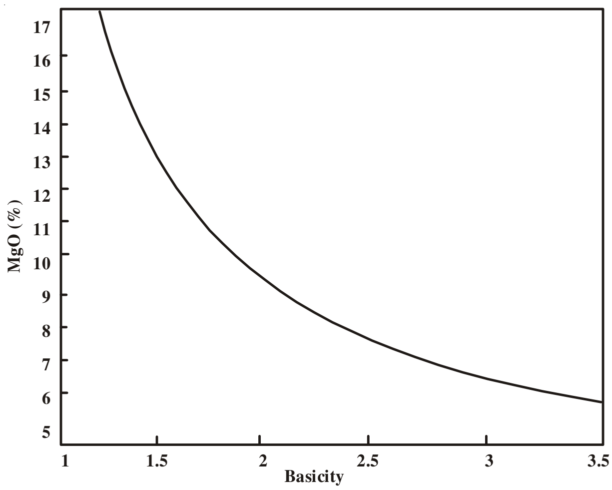


Fig. 1. Solubility of MgO for slags that are dual saturated with respect to CaO and MgO is depicted at 1600 ºC

For slag with a basicity ratio more than 3.5, the solubility limit levels off to about 6-5.5 percent MgO, at which point it remains constant in the CaO-MgO-FeO system.

Another important feature of this diagram is the significant increase in MgO solubility (with decreasing basicity) for slags with basicity levels less than 2 in some cases. The initial slag formed in the EAF might have a low basicity, resulting in a higher MgO solubility.

The data on MgO solubility as a function of slag basicity in Fig. 1 is important, as it defines the minimum amount of MgO required in the slag for refractory compatibility. However the current format, relating the data in this figure to foaming properties in the EAF is difficult. As mentioned, FeO is the distinct impact on foaming properties.

In other side, there is straight proportional between percentage of FeO and MgO in slag (Figs. 2-4). you can find that the importance of the initial MgO content of the slag. If the initial MgO level is too low. the window of effective foaming (as a function of FeO content) is small.

TABLE-2
CHEMICAL COMPOSITION OF PRIMARY SLAG FROM MOBARAKEH STEEL COMPANY

Sample	SiO_2 (%)	Al_2O_3 (%)	Na_2O (%)	MgO (%)	K_2O (%)	TIO_2 (%)	MnO (%)	CaO (%)	FeO (%)	P_2O_5 (%)	SO_3 (%)
Percentage	18.08	3.42	0.35	4.88	0.07	1.31	0.66	33.77	35.85	0.56	0.03

TABLE-3
CHEMICAL COMPOSITION ACCORDING TO TEST METHOD 1 AND 2

Reduction sample	SiO_2	Al_2O_3	Na_2O	MgO	K_2O	T_1O_2	MnO	CaO	FeO	P_2O_5	So_3
Test1	38.23	6.12	2.55	10.02	0.09	1.31	0.70	31.46	7.62	0.27	0.17
Test 2	29.70	4.32	1.01	10.41	0.08	1.40	0.92	35.64	14.20	0.72	0.25

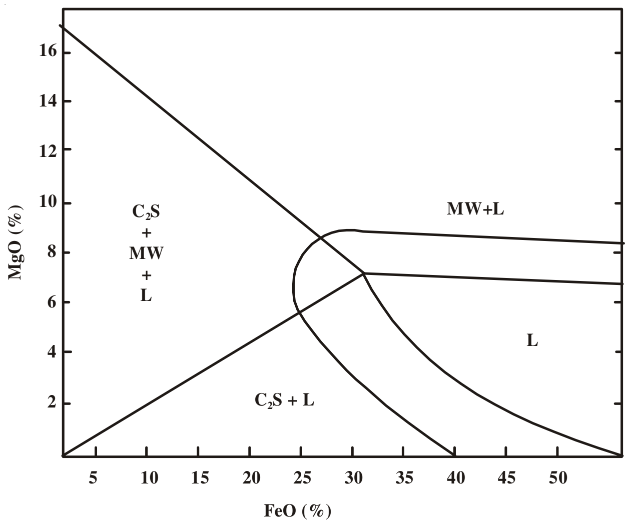


Fig. 2. An ISD is shown for a basicity (B) of 2

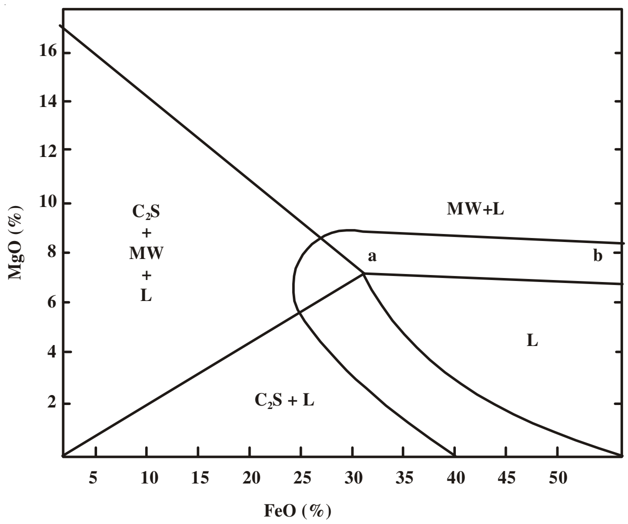


Fig. 3. An ISD is shown for a basicity (B) of 2.5

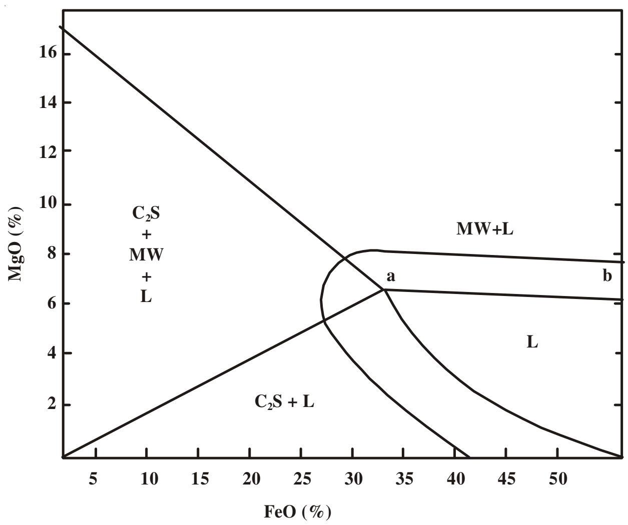


Fig. 4. An ISD is shown for a basicity (B) of 3

On decreasing the amount of FeO in slag, it will decrease the slag basicity and will increase the per cent of MgO consumption in slag.

For this issue and for decreasing the refractories consumption, the second stage of iron recycling has done. List of raw materials for this new test (test-2) is mentioned in Table-1.

In this new test, the amount of silicon oxide has decreased and mixture compositions change to 10 kg slag that was mixed by 600 g coke powder (mesh 30), 50 g silicon oxide and 100 g Frugen H6 as flux and metal protection. In this new test method, the amount of SiO_2 has decreased from 1000 to 50 g.

In the second test, the portion of FeO after reduction has decreased less that 14 % and according to Table-3 slag basicity (CaO/SiO_2) was increased to 1.7 (B:1.7). This is shown slag basicity change from (B:1) to B:1.7 at test 2.

With this new test, we can protect refractory from acidic slag and can recycle iron more than 60 %.

Conclusion

The initial FeO content and slag basicity on the process show trends similar to these in reduction by solid carbon. Problems and benefits of the recycling of electric arc furnace slags are discussed. The most important item in iron recycling is refractories consumption. Decreasing of FeO portion by solid carbon is effective on basicity.

REFERENCES

1. L. Mihok, P. Demeter, D. Baricova and K. Seilerova, *Metalurgija*, **45**, 163 (2006).
2. Utilization of Blast Furnace and Basic Oxygen Furnace Slags, International Iron and Steel Institute, Brussels (1987).
3. European commission, Best Available Techniques in Production of Pig Iron and Steel (2004).
4. D.J. Min, J.W. Han and W.S. Chung, *Metallurg. Mater. Trans. B*, **30**, 215 (1999).
5. B. Sarma, A.W. Cramb and R.J. Fruehan, *Metallurg. Mater. Trans. B*, **27**, 717 (1996).
6. E.B. Pretorius and R.C. Carlisle, *Iron & Steel making*, 79 (1999).