Recovery of Alumina from Electroslag-Remelting of Ti-Bearing Blast Furnace Slag

Songli Liu
Resources and Environmental Engineering College of Panzhihua University
Materials Science and Engineering College of Xihua University
Panzhihua of SiChuan Province, China
e-mail: pzhlsll@163.com

Junyi Xiang
Resources and Environmental Engineering College of Panzhihua University
Materials Science and Engineering College of Xihua University
Panzhihua of SiChuan Province, China

Li Cao
Resources and Environmental Engineering College of Panzhihua University
Materials Science and Engineering College of Xihua University
Panzhihua of SiChuan Province, China

Pan Huang
Resources and Environmental Engineering College of Panzhihua University
Materials Science and Engineering College of Xihua University
Panzhihua of SiChuan Province, China

Kuisong Zhu
Resources and Environmental Engineering College of Panzhihua University
Panzhihua of SiChuan Province, China

Abstract—The recovery of alumina from electroslag-remelting of Ti-bearing blast furnace slag has been investigated by Bayer process, XRD methods. The effects of NaOH concentration , ratio of liquid to solid, leaching time and temperature, particle size, precipitating time and temperature, calcining temperature and time were investigated. With leaching, filtering, precipitating and calcining, alumina recovery of 75.56 pct was obtained under the conditions of NaOH concentration of 260 g/l, ratio of liquid to solid of 5:1, particle size of 85 pct passing 0.074 mm, leaching at 373 K (100°C) for 160 minutes , precipitating at 313 K (40°C) for 35 minutes and Calcining at 1473 K (1200°C) for 3 hours.

Keywords- Alumina; Blast furnace slag; Bayer process; Electroslag-remelting;Recovery

I. INTRODUCTION

Vanadium-titanium-magnetite concentrate is composite ore containing iron, vanadium and titanium, in addition to many other valuable metals (such as Sc, Cr, Ga, Co, etc.). The current process of blast furnace, converter v-recovering and titanium concentrates beneficiation for this kind of mine only makes use of 68% iron, 47% vanadium and 15% titanium[1],which produces a large amount of blast furnace slag containing 22–25% TiO_2. This slag has already accumulated 50 million tons so far, and it is still increasing at a rate of 3 million tons per year[2], resulting in a waste of resources and environment pollution. Therefore, how to recover these Ti-bearing blast furnace slag economically is very significant.

Several studies[3-10] on comprehensive utilisation of Ti-bearing blast furnace slag have been carried out in China from the 1960s. Many of the programs can be divided into two categories: the one is the technology of non-extraction titanium. Using this technique the blast furnace slag containing titanium is directly produced into the building materials or other products. The other is to extract titanium and other valuable components through the metallurgical process [11]. Using aluminothermy process, Al-Si-Ti alloy was obtained as the reduction reagent for waste aluminum. TiO_2 and SiO_2 in the blast furnace slag were reduced in an electroslag-remelting furnace. Since most of silicon and titanium were replaced by aluminum, Ti-bearing blast furnace slag turned into Al-bearing slag. Fortunately, when the molten slag was carefully treated in a slag ladle after it effused from the electroslag remelting furnace, most alumina in slag could be settled and separated. Thus, the Al-bearing slag became the raw material instead of waste product. The purpose of the present research is to study the settlement behavior of alumina in the slag. Additionally, it may provide a useful method for separating alumina from Al-bearing slag .

II. EXPERIMENTAL

A. Materials

Ti-bearing blast furnace slag used in this works were provided by mill of China iron and steel company. Ti-bearing blast furnace slag and waste aluminum were injected into an electroslag remelting furnace. After reducing for 10 min, the molten slag was slowly cooled down at a cooling rate of 3-5K/min for about 4 h. The slag obtained after these treatments was called Al-bearing slag. The bottom Al-bearing slag was crushed and the Al-Si-Ti droplets were taken out by magnetic separation for weighing. Table 1 indicated the compositions of Ti-bearing blast furnace slag and Al-bearing slag.

Table 1 Chemical composition of slag, wt-(%)

Ti-bearing slag	Al-bearing slag							
Al_2O_3	CaO	SiO_2	Al_2O_3	MgO	MnO_2	FeO	TiO_2	Ti_2O_3
20.23	29.5	5.64	48.22	8.06	0.103	1.03	2.98	1.05
22.19	29.6	3.16	53.19	8.31	0.09	0.92	1.13	1.17
24.25	29.65	1.99	57.66	8.02	0.102	0.89	0.52	1.29

B. Alumina recovery procedures

Three procedures were applied to recover alumina from Al-bearing slag: (i) leaching of the aluminium content of Al-bearing slag in the form of soluble sodium aluminate, (ii) transformation of the aluminium content of sodium aluminate into a precipitation, and (iii) filtration, washing, drying and calcination of the precipitates.

Al-bearing slags were leached in a glass beaker (0.5dm3) heated in an isothermal temperature water bath, equipped with a mechanical stirrer and a temperature controller. In each batch, 50 g of Al-bearing slags (dry weight, precision 0.1 mg) were added into an aqueous NaOH solution of the required concentration and volume at the required temperature. A mechanical glass stirrer was operated at a speed of 350 rpm.During stirring, lime (CaO) for desilication purposes was added (0.3% of the amount of Al-bearing sla), and sufficient water was subsequently added to maintain the total volume constant. When the leaching process was finished, solution and residues were separated by filtering under vacuum, and washed thoroughly with distilled water until a constant filtrate volume was obtained. The collected filtrate was subjected to chemical analysis.

A 1 dm^3 portion of sodium aluminate solution ($130g \cdot dm^{-3}$) was mixed with freshly prepared aluminium hydroxide gel in a $2dm^3$ glass beaker. The content of Al_2O_3 in the added gel was 42g, which was equivalent to about 40% of the Al_2O_3 content of the aluminate solution. The mixture was stirred for a few minutes and ensured homogeneity, then a stream of air was passed throughout via a diaphragm pump for 20h at 30°C. Subsequently, the precipitate was filtered, washed and dried. Calcination of the dried materials was conducted in a static atmosphere of air at various temperatures (Tc=200-1200°C) for 3h, using a temperature controlled muffle furnace. The collected products were subjected to XRD and chemical analysis.

III. RESULTS AND DISCUSSION

A. Effect of NaOH concentration on the recovery of alumina

Figure 1 shows NaOH concentration on the recovery of alumina at 373 K (100°C) for 160 minutes by keeping a ratio of liquid to solid of 5:1 and a particle size of 85 pct passing 0.074mm sieve. It is found that the recovery of alumina increases evidently when NaOH concentration increases from 100 to 260 g/l. Increasing NaOH concentration will help to increase internal diffusion, which leads to the increase of recovering alumina. Figure 1 also illustrates that the recovery of alumina difference between NaOH concentration of 260 and 300 g/l is quite small. It may be explained that as NaOH concentration continued to increase, the driving forces of diffusion reactions became low above a certain NaOH concentrate, which led to less effect on the recovery of alumina.

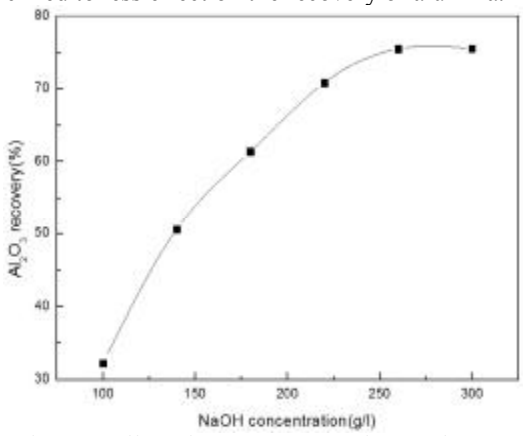

Figure 1. Effect of NaOH concentration on the recovery of Al_2O_3

B. Effect of ratio of liquid to solid on the recovery of alumina

The effect of ratio of liquid to solid on the recovery of alumina was studied at NaOH concentration of 260 g/l, particle size of 85 pct passing 0.074 mm, and leaching at 373 K (100°C) for 160 minutes. As shown in Figure 2, it is clear that the recovery of alumina increases significantly when increasing ratio of liquid to solid in the initial stage(the carbon/ore ratio from 2.0 to 5.0) and then almost levels off. It indicates that an effective increase of the recovery of alumina can be achieved by increasing the ratio of liquid to solid. With the increase of ratio of liquid to solid, the contacting area between solution and particles increases, which accelerates the reaction of particles and NaOH solution.

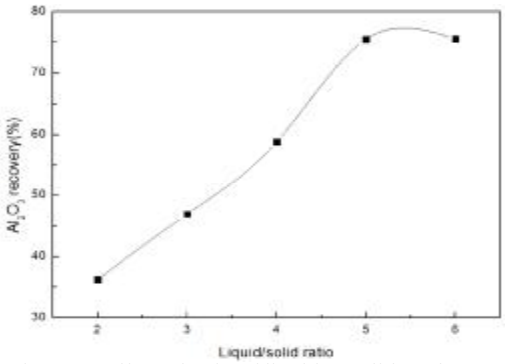

Figure 2. Effect of ratio of liquid to solid on the recovery of Al_2O_3

C. *Effect of time (tm) and temperature (Tp) in leaching on the recovery of alumina.*

The effect of leaching time (tm) on the recovery of alumina at different leaching temperature (Tp) are performed in Figure 3. It is found that a value of 75% recovery was obtained at 100°C, as compared with 65 and 45% at 90 and 80°C, respectively. Figure 3 also shows the initial high rate of leaching to slow down markedly after the elapse of 160min of leaching, regardless of the temperature applied.

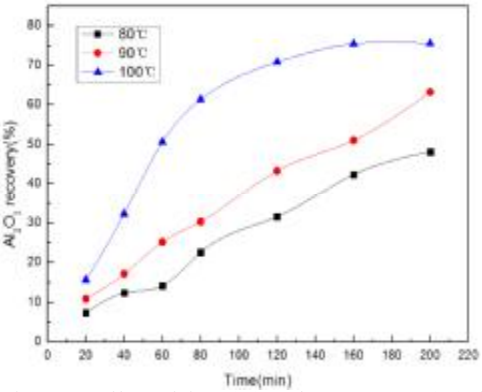

Figure 3. Effect of time (t_m) and temperature (T_p) in leaching on the recovery of Al_2O_3

D. *Effect of particle size on the recovery of alumina*

The effect of particle size on the recovery of alumina was examined under the conditions of NaOH concentration of 260 g/l, ratio of liquid to solid of 5:1, and leaching at 373 K (100°C) for 160 minutes. As shown in Figure 4, It can be seen that by increasing the particle size of the Al-bearing slags, the recovery of Al_2O_3 increased. However, the Al_2O_3 recovery is still lower than 80 even though 95 pct of the particles are passing 0.074mm sieve. The reason is that some impurities of the alumina do not dissolve in a NaOH solution.

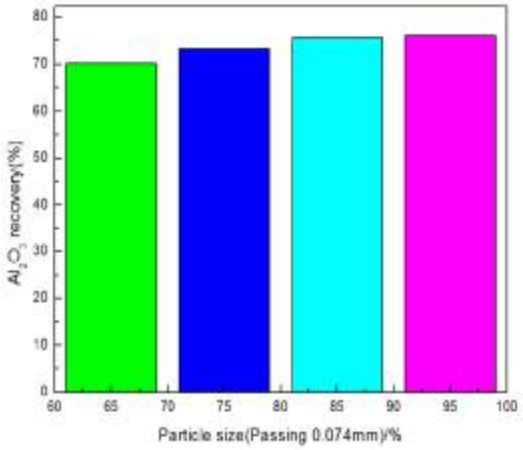

Figure 4. Effect of particle size on the recovery of Al_2O_3

E. *Effect of time (tm) and temperature (Tp) in precipitating on the recovery of alumina*

The effect of precipitating time (tm) on the recovery of alumina at different leaching temperature (Tp) are performed in Figure 5. It is found that all the curves of alumina recovery show a similar trend in just the slope at temperature from 40 to 70°C region. The recovery of alumina decreases evidently when precipitating temperature increases from 40 to 70°C.The alumina recovery at a given temperature increases with the increase of precipitating time, decreases when the time is above 35min.

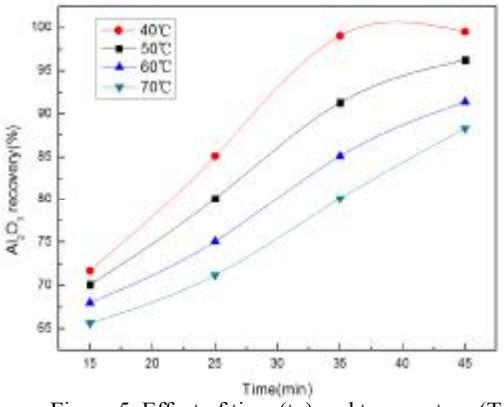

Figure 5. Effect of time (t_m) and temperature (T_p) in precipitating on the recovery of Al_2O_3

F. *XRD analysis of calcined alumina*

Figures 6 illustrates x-ray analysis of Al-bearing slag and product. From which it is clear that the main phase of Al-bearing slag is $2CaO{\cdot}Al_2O_3{\cdot}SiO_2$,$12CaO{\cdot}7Al_2O_3$, $CaO{\cdot}Al_2O_3$, $CaO{\cdot}SiO_2$.By leaching , precipitating and calcination, alumina is produced. In addition, some impurities have remained unreacted in the alumina, and the utilization of alumina will be studied in further research.

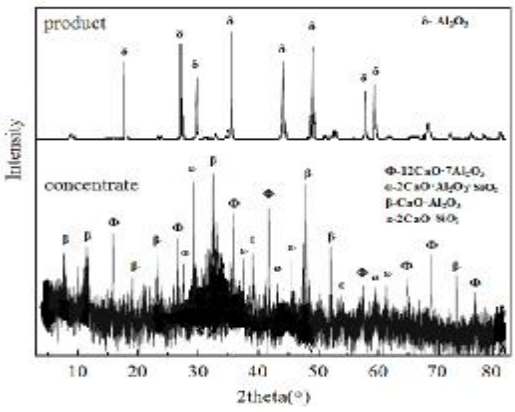

Figure 6. XRD results of Al-bearing slag and product

IV. CONCLUSIONS

In this study, recovery of alumina from electroslag-remelting of Ti-bearing blast furnace slag was investigated. The experiments prove that recovering alumina from Al-bearing slag by the Bayer process is an effective method. Alumina and other impurities were separated effectively after leaching and filtering. The results show that alumina recovery of 75.56 pct was obtained under the conditions of NaOH concentration of 260 g/l, ratio of liquid to solid of 5:1, particle size of 85 pct passing 0.074 mm, leaching at 373 K (100°C) for 160 minutes , precipitating at 313 K (40°C) for 35 minutes and Calcining at 1473 K (1200°C) for 3 hours.

ACKNOWLEDGMENT

This research is supported by SiChuan province Natural Science Foundation (2010JY0112) and Innovation Program of Panzhihua Municipal Science Technology Commission (2010CY-G-9).

REFERENCES

[1] Jun Deng, Xun Xue, Guogong Liu: Current situation and development of comprehensive utilization of vanadium-bearing titanomagnetite at PanGang. submitted to *Journal of Materials and Metallurgy,* 6(2),pp.83-86,2007 .

[2] Mingyu Wang:Separation of iron droplets from titania bearing slag. submitted to *Journal of iron and steel research,international* , 15(1) , pp45-48,2008.

[3] Xinghua Li, Jingtao Pu: The latest developments of integrated utilization on Panzhihua high titanium-bearing BF slag . Iron Steel Vanadium Titanium,32(2),pp10-14,2011.

[4] [4] Qingqiang Weng: High Ti-beard slag comprehensive utilization out line and forecast. volume 31 of Progress in Sichuan Metallurgy, chapter,31(6),pp40-42,2009.

[5] Tiechui Yuan, Honggui Liu: Preparation of rich-titanium materials from blast furnace slag containing titanium . submitted to *Journal of Hunan Nonferrous Metal*, 25(4),pp38-40 ,2009.

[6] Wengxin Zhang, Zhencai Li: Study on the core-loss trend and distribution of Pan Gang's blasturnace. submitted to *Journal of chongqing college of iron and steel technology*,14(2), pp5,1999.

[7] Sijia Wang, Yue Zhang, Xiangxin Xue, et al:Recovery of titanium form titanium-bearing blast furnace slag by ammonium sulfate melting method, submitted to *Journal of CIESC journal*,63(3),pp991-995,2012.

[8] Xinghua Li, Xuesong Wang, Zhilu Liu, et al: The new direction of comprehensive utilization of high Titanium-bearing slag. submitted to *Journal of Iron Steel Vanadium Titanium*, 12(3), pp10-16,2009.

[9] Mingyu Wang,Xuewen Wang,Yuehui He, et al: Isothermal precipitation and growth process of perovskite phase in oxidized titanium bearing slag. submitted to *Transaction of Nonferrous Metals Society of China ,18(3),pp459-462,2008.*

[10] Xiaohua Liu, Zhitong Sui: Leaching of Ti-bearing blast furnace slag by pressuring. submitted to *The Chinese Journal of Nonferrous Metal, 12(6),pp1281-1284,2002.*

[11] Huadong Liao: Study on separating titanium form the high titanium-bearing blast furnace slag of Pangang. Chong Qing: Chong Qing University, 2006.