A Novel Method for Recovering Iron from Waste Slag Generated in Top Submerged Lance (TSL) Plant at Zinc Refinery

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1. Introduction

At the present, over 1.8 million tons of slags are produced from the nonferrous metal smelters such as copper, lead, and zinc in Korea each year. These slags contain about 30–40 wt% iron, and the rest is mostly the ceramic components like SiO_2, CaO, and Al_2O_3. It is very interesting to recover iron and ceramic components from the slag from the view point of resource recycling, besides addressing the problem of disposal on the land. In this study, a novel process has been developed to recover iron from the waste slag, which is generated from a top submerged lance (TSL) Plant at the Zinc Refinery, Korea. The process involves firstly the crushing of waste slag, followed by the reduction roasting with a suitable carbonaceous reductant in a furnace. And then, the resulting material is again crushed and ground, followed by wet magnetic separation to recover metallic iron and ceramic.

2. Experimental

2.1. Materials

The waste slag used in the experiments is discarded from a top submerged lance (TSL) Plant at the Zinc Refinery, Korea. At the TSL plant, the waste slag was granulated and cooled quickly by spraying with water. The waste slag was verified to have a complex amorphous structure by X-ray analysis. This is the reason that a quick solidification by such water spray cooling provides amorphous granulated slag. Table 1 shows the average chemical compositions of the waste slag. The main ingredients contained in the waste slag are 33.4 wt.% FeO and 24.43 wt.% SiO_2.

Table 1. Average chemical compositions of the waste slag generated from a top submerged lance (TSL) Plant.

Metals	T. Fe	FeO	Fe_2O_3	SiO_2	CaO	Al_2O_3	MgO	ZnO	Cu	Pb
Composition (%)	35.1	33.4	13.06	24.43	9.07	5.58	1.01	4.7	0.85	0.36

2.2. Methods

The waste slag was first ground to the particle size of −74 μm by jaw crusher, hammer mill and rod mill. The ground waste slag was uniformly mixed with the coke and then charged into an electric resistance furnace for the reduction reaction at a temperature of 1,050~1,150 °C for 30~90 min. Afterwards, the sample was subjected to wet magnetic separation, and then both magnetic and non-magnetic products were analyzed. Also, the morphological characterization of the samples was performed using a scanning electron microscope (SEM, JSM-6380LV, JEOL Ltd, Tokyo, Japan) equipped with an energy dispersive X-ray spectrometer (EDS, Link Isis 3.0, Oxford Instrument plc, Oxon, U.K.).

3. Results and discussion

The reduction reaction of waste slag is to convert iron oxides contained in the waste slag to magnetic substances for the subsequent magnetic separation. The iron oxides contained in the waste slag exist in complex amorphous states bound to silica, alumina, lime, etc. Thus, in order to effectively convert the amorphous iron oxides to magnetic substances, the reduction reaction of the waste slag with coke was carried out at a relatively high temperature of 1150 °C for 90 min, in which the waste slag was not melted. Before the magnetic separation, the waste slag reduced by the reduction reaction step was ground to the particle size of –75μm for the liberation of the iron-rich parts from the remaining silicon-rich parts. And then, several wet magnetic separation runs were performed to separate the iron-rich part from the reduced waste slag out of the remaining compounds such as silicon, lime, and aluminum. The results are shown in Fig. 1. The recovery efficiency and grade of iron are more than 75% and 65%, respectively. The total content of non-ferrous metals, which are harmful elements in steel industry, including copper, zinc and lead in the magnetic product is around 1 wt.%, while the grade of iron is over 65 wt.%. Thus, the magnetic products should be used as an iron resource for making pig iron, if treated suitably.

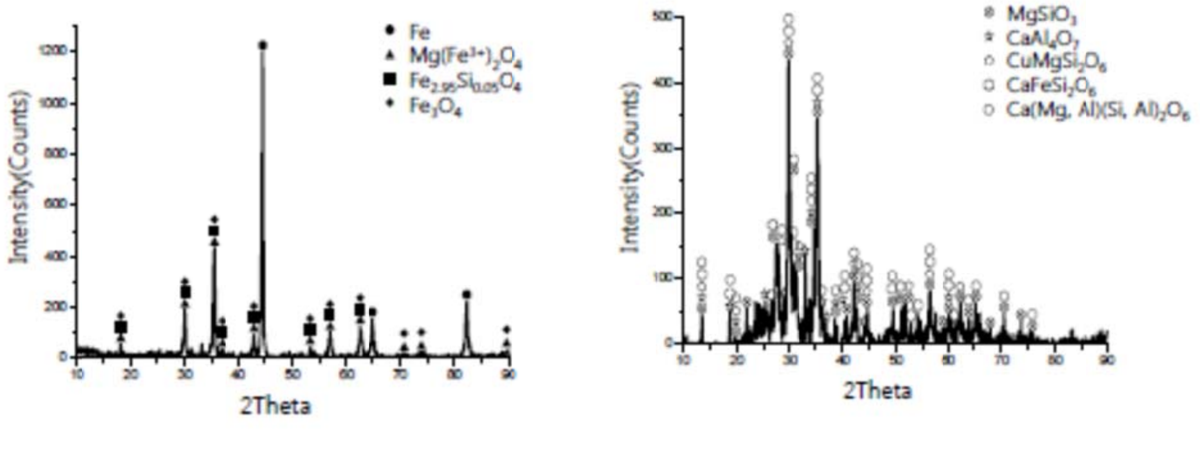

Figure 1. XRD patterns of the magnetic (left) and non-magnetic (right) products obtained from the reduced waste slag by the magnetic separation.

4. Conclusions

Based on the above results, it is considered that the proposed process scheme is a possible method for the upgrading of iron from the waste slag to utilize it as an iron raw resource for manufacturing pig iron.