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Short Communication

A Study on the Manufacture of Iron Ore Substitute by Classification and Magnetic Separation

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Abstract *- In this study, an experiment was conducted to manufacture an iron ore substitute by increasing the Fe quality in the steelmaking dust treatment DRI through classification and magnetic screening. 1 kg of steelmaking dust treatment DRI was separated, and the weight ratio and Fe content by granularity were investigated. Afterwards, a magnetic screening experiment was conducted with 100 g of DRI separated based on the derived optimal separation conditions. For magnetic screening, the weight and Fe content of the magnetic powder for each Gauss were investigated using the magnetic strength (Gs) as a variable using an electromagnet and a Gauss meter; there are capable of controlling the magnetic strength. As a result of the experiment, the Fe content in DRI was improved from 43.29 wt.% to 61.02 wt.% through separation and magnetic screening, thus achieving the requirements of iron ore substitute.*

Keywords *- Steelmaking dust, DRI, Separation, Magnetic screening, Iron ore substitute.*

1. Introduction

Among domestic designated wastes, steelmaking dust is inevitably generated at a high temperature of 1600℃ or higher during steel production through an electric furnace. Approximately 15 to 25 kg of dust is generated when producing 1 ton of iron [2, 4]. According to the Korea Iron and Steel Association, electric furnace steel production is expected to be 22.2 million tons as of 2022. Accordingly, the amount of dust generated in steelmaking is estimated to exceed 30,000 tons. Although there are some differences depending on the type of iron scrap and the processing method, steelmaking dust contains about 20 to 40% of zinc and 10 to 25% of iron, as well as heavy metals such as lead, manganese, copper, and cadmium, and negative ions such as chlorine and fluorine.

These dusts, lime, and coke are charged into a rotary reduction kiln to reductively distill zinc into the gas phase to produce crude zinc oxide [6]. At this time, crude zinc oxide is recovered in the form of powder in the filter, and the residue in the kiln is produced as a by-product of the process. This residue contains residual zinc and iron, and the iron is reduced by the coke charged together and remains in the form of reduced iron (Direct Reduced Iron, DRI). These by-products from the process are called steelmaking dust treatment DRI and contain about 5 to 10% of zinc and 40 to 55% of iron. Despite the fact that the steeling-making dust contains a large amount of iron, it is classified as a designated waste due to the lack of treatment technology and social interest. It is landfilled at the cost of KRW200,000 to 300,000 per ton. As a result, soil and water pollution around the landfill site and economic loss occurs, and it is necessary to develop a process for recycling steelmaking dust treatment DRI. Therefore, this study was conducted to investigate the optimal process conditions for using DRI as a substitute for iron scrap and iron ore by separating DRI with high Fe content from the steelmaking dust treatment DRI, which is currently landfilled.

2. Experiment

Direct Reduced Iron (DRI), a process by-product generated when crude zinc oxide is produced from steelmaking dust, was used for the sample used in this study. XRF (X-Ray Fluorescence) analysis was used conducted to analyze the Fe content and chemical composition of the raw material. The analysis results are presented in Table 1. As a result of XRF analysis, it was confirmed that Fe was 43.49wt.%.

Table 1. Chemical composition of DRI

Element	Wt.%
Fe	43.49
Ca	29.99
Si	8.26
Al	5.64
Zn	4.09
Mn	3.25
Mg	1.61
Na	1.60
S	1.01
Cr	0.78
Ti	0.28

2.1. Separation Experiment for Steelmaking Dust Treatment DRI

Steelmaking dust treatment DRI is collected in the form of a clinker, and the shape and granule size is irregular. In order to investigate the weight and Fe content by granule size, samples were pulverized and classified. In the experiment, 1 kg of DRI raw material was separated to mm or less using a ball mill. The weight was measured at granule sizes of 75µm or less, 75 to 150µm, 150 to 300µm, 300 to 500µm, 500 to 600µm, and 600µm to 1 mm, respectively, and the Fe content was determined through XRF analysis.

2.2. Magnetic Screening of the Residues After Separation

Based on the derived separation conditions, a magnetic screening experiment was conducted. This is a process to select samples with high Fe content by using the magnetism of Fe in the steelmaking dust treatment DRI. An electromagnet capable of magnetic force control was used, and the magnetic field strength was measured using a Gauss meter under conditions of 500, 1500, 3000, 3500, and 4000Gs experiment was conducted. Since Fe is self-attached and impurity components are self-attached during the magnetic screening, an air-blowing of the self-attached powder was conducted.

3. Results and Discussion

3.1. Separation from Steelmaking Dust Treatment DRI

Table 2 presents the weight and ratio of DRI after separation. Figure 1 presents the change in Fe content according to the granularity measured by XRF analysis during classification and separation. It was 16.92 wt.% below 75 µm, 31.73 wt.% between 75 and 150 µm, 44.47 wt.% between 150 and 300 µm, 47.56 wt.% between 300-500 µm, 50.23 wt.% between 500 and 600 µm, and 50.80 wt.% between 600 µm and 1 mm.

As a result of the experiment, it was found that samples of 150 µm or less accounted for 7.47% of the total weight, and they were separated due to their low weight ratio and low Fe content. Most of the samples between 150 µm and 1 mm were recovered, and it was found that it accounted for 92.49% of the weight of DRI, the raw material. The Fe content was improved in this granularity range, and 150 µm to 1 mm was determined as the optimal separation condition.

Table 2. Chemical composition of DRI

Granularity(µm)	Weight(g)	Ratio(%)
<75	27.12	3.12
75~150	37.72	4.35
150~300	196.72	22.69
300~500	233.18	26.89
500~600	122.74	14.15
600~1000	249.38	28.76

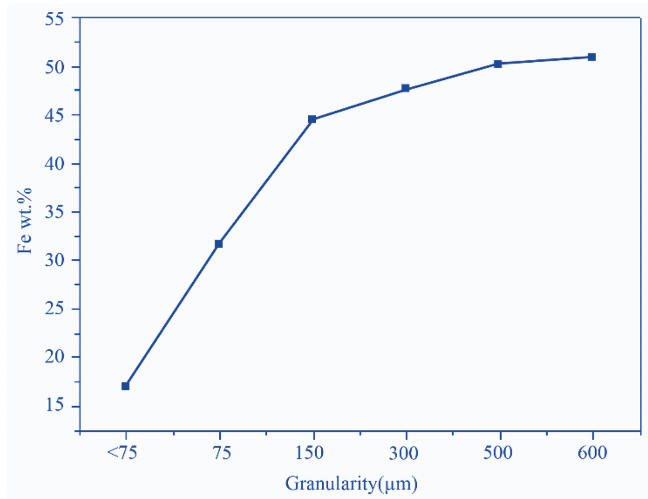

Fig. 1 Fe content by granularity (XRF)

3.2. Magnetic screening from the residues after separation

A magnetic screening experiment was conducted with 100 g of DRI separated from 150 µm to 1 mm. Table 3 presented the weight and ratio of magnetic self-attached granules by magnetic strength (Gs) when DRI was 1 kg. Figure 2 presents the change of Fe content according to the Gaussian conditions. The Fe content was 67.11 wt.% at 500Gs, 63.36 wt.% at 1500Gs, 61.02 wt.% at 3000Gs, 55.58 wt.% at 3500Gs, and 51.32 wt.% at 4000Gs. As a result of the experiment, it was confirmed that when the magnetic force is weak, the Fe content is high, but a small amount of self-attached powder is recovered, and when the magnetic force is strong, a large amount of self-attached powder is recovered, but the sample with low Fe content is also self-attached. The quality of iron ore used in the steelmaking process is 60% or higher, and it is considered that magnets of 3000Gs or less must be used to use it as an alternative to iron ore. In consideration of even the ratio of self-attached DRI, 3000Gs was determined as the optimal magnetic force condition.

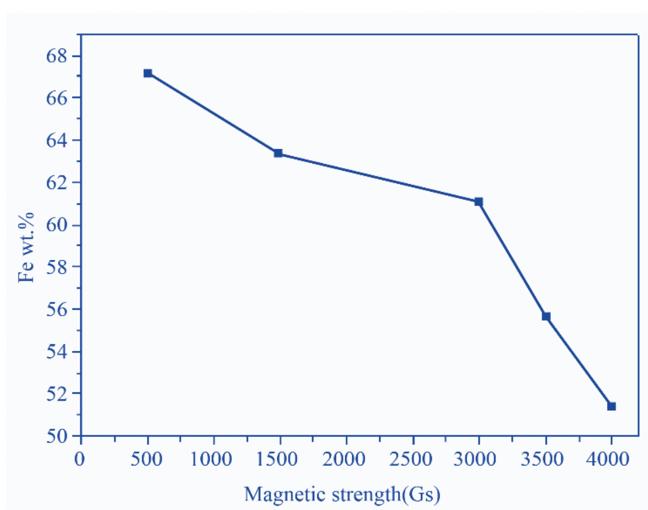

Fig. 2 Fe content by magnetic strength (XRF)

Table 3. Weight and ratio of attached powder magnetic strength

Magnetic strength(Gs)	Weight(g)	Ratio (%)
500	12.03	12.03
1500	30.77	30.77
3000	67.81	67.81
3500	77.32	77.32
4000	85.56	85.56

4. Conclusion

In this study, separations were conducted to manufacture iron ore substitutes from steelmaking dust treatment DRI. As a result of XRF analysis, it was found that the Fe content of the raw material DRI was 43.49 wt.%. Separation was conducted to confirm the Fe content and weight of each granularity of the DRI, the raw material. As a result of the experiment, 92.49% of DRI was recovered between 150μm and 1mm, and Fe content was improved by 4.78% in this granularity range. Therefore 150μm ~ 1mm was determined as the optimal classification condition. After that, the separated DRIs were subjected to a magnetic experiment according to magnetic force strength. As a result of the magnetic screening experiment, it was confirmed that when the magnetic force is weak, the Fe content is high, but a small amount of self-attached powder is recovered. Accordingly, considering the ratio of Fe content and self-attached powder, 3000Gs was determined as the optimal condition. At this time, it was confirmed that 67.81% was self-attached, and the Fe content was 61.02 wt.%.

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