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# RECOVERY OF METALS FROM EAF DUST WITH RAPID SYSTEM

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The dust generated from the electric arc furnace steel making process is classified as hazardous material by Korean Environmental Protection Acts, mainly because of the existence of water leachable Pb, Zn and Cd. Thus the treatment of EAF dust is being carried out to fulfill both the environmental aspect and recovery of valuable metals. To establish the proper process for recovering the valuable metals (Fe, Zn, Pb and Cd) and producing the non-toxic slag from EAF dust, using RAPID-10 system, feasibility study have been carried out. To find out the scale-up factor for designing the commercial scale EAF dust treatment process(capacity : 50,000 ton EAF dust per year) entilted RAPID-50 system.
The design and construction of RAPID-50 (RIST Arc Plasma Industrial Device) system for treating 50,000 ton of EAF dust per year is now undergoing. Overall plan for treating EAF dust generated in KOREA will be setup after successful operation (December, 2002) of RAPID-50 system.

Keywords: EAF dust, Plasma, RAPID System, Hazardous material

## Introduction

Electric arc furnace dust (EAF dust) generated from a mini-mill process is classified as a hazardous material. With ever-increasing environmental awareness, regulations concerning the proper treatment of EAF dust have become more severe.
Dust, as a basic material in the high concentration metal oxide, is produced through charging, smelting and discharge of raw materials and hot metal during the operation of electric arc furnace. However, the composition of it varies from the operation condition. Dust should be regarded as the most important raw material for the recovery of metal values because of its quantity. Amount of these dust generated in KOREA is known by about 350,000 ton per year.
Generally, to establish the adequate process for recycling of this kind of waste materials, three major processes have been proposed by many researchers. These would be pyrometallurgical process, hydrometallurgical process and landfill.
However, later two processes were discarded in our study because it might cause secondary pollution. In case of landfill, large area is required and it has high possibility to induce secondary pollution due to the leachability of heavy metal by ground water.

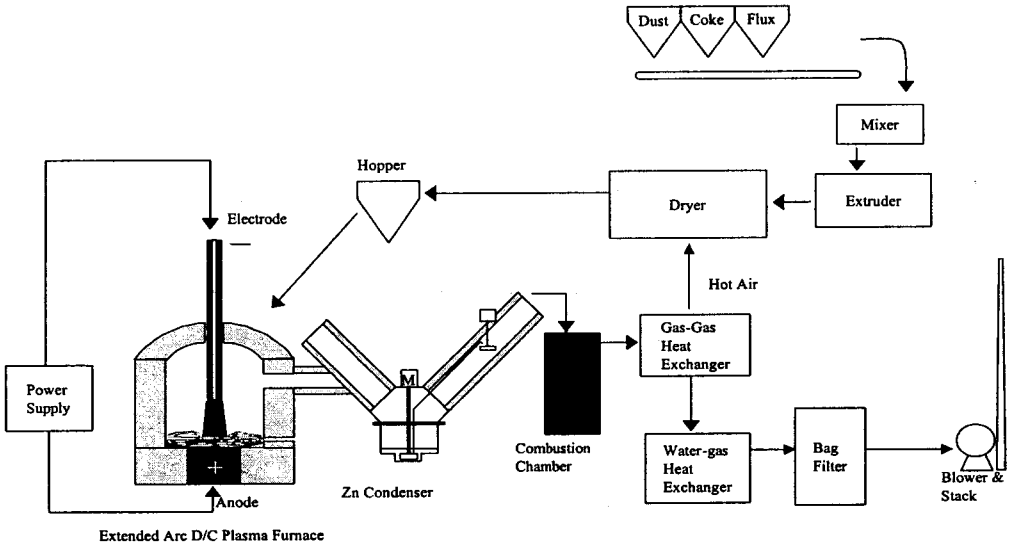


Fig.1 Schematic drawing of RAPID-10 system

From a metallurgical and recycling point of view, the dust could be regarded as a raw material for Fe and Zn source. We have to give a special attention to the EAF dust as they have lots of valuable metal, for instance Fe, Zn, Pb etc and its amount. Thus the treatment of EAF dust by pyrometallurgical process is being carried out to fulfill both the environmental aspect and recovery of valuable metals.

To recover the Zn and Fe from the EAF dust, several pyrometallurgical systems are proposed. However interest are concentrated on the "plasma method" because of the flexibility and it's space considering concept. Using the "plasma method", sufficient radiation of heat to the upper part of the reactor allows the particulate material to react rapidly. But the heat input into the melts becomes small, considerable amounts of the heat is wasted with exhausted gas, and this is mainly caused by the limitation of plasma process. To overcome these disadvantages of plasma method, so called RAPID (RIST Arc Plasma Industrial Device) using extended arc plasma, has been developed by RIST and the results were reported last time.

In this paper, the results and characteristics of RAPID-10 (capacity ; 10,000 t/y) system is reported.

**Overview of RAPID-10 System**

The RAPID-10 system (RIST Arc Plasma Industrial Device) is developed on the base of the experience of designing and operation of RAPID proto-type.

A plasma arc length has been controlled from 300 to 350 mm, to distribute thermal energy to a bath and a furnace properly.

The Zn-Condenser is designed to increase a reaction path. Plasma is the adequate tool for future environmental, space and economic consideration.

Fig.1 shows the schematic diagram of RAPID-10 system which consists of a main reactor, a cathode, a Zn-condenser, dust pre-treatment facilities and a waste gas treatment system. The Zn-condenser is designed to be a V-shape to increase Zn-recovery. Pb splashing units are attached to Zn condenser to

recover metallic Zn directly. Fig.2 shows the overview of RAPID-10 system located at R-tec.

RAPID-10 system is composed of 3 main parts.

1. Dust pre-treatment Facilities

EAF dust reserved in scaled silo, is mixed with coke(reducing agent), and flux. And pre-mixed raw material is pelletized by extruder and drying process is followed.

2. PLASMA FURNACE & Zn CONDENSER

The plasma furnace consists of cathode, anode and furnace body. The main part of cathode is consisted with graphite electrode and water cooled copper tube. In a furnace body, EAF dusts are melted, reduced and vaporized to metallic Zn vapor. The reduced iron and slag are tapped through a tap-hole. The vaporized Zn from reactor is captured by lead under the controlled temperature by splashed Pb. This Zn condenser is designed under the consideration of long reaction path.

3. WASTE GAS TREATMENT SYSTEM

To satisfy environmental regulations, waste gas treatment system- cyclone, bag filter, heat exchanger (for supplying hot air to drier)- are attached to RAPID-10 system.

Fig.2(a) Overview of the main f'ce and Zn condenser in RAPID-10 system

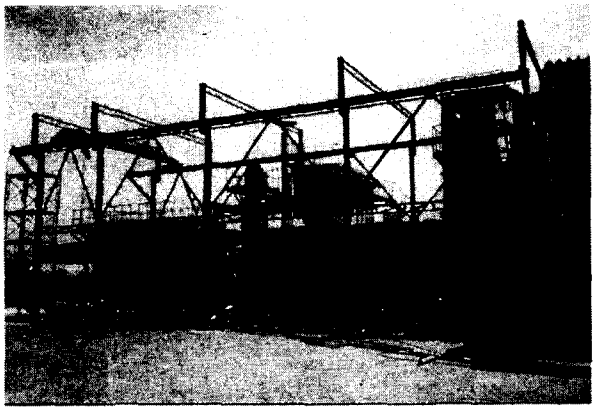

Fig.2(b) Overview of the EAF dust pretreatment process in RAPID-10 system

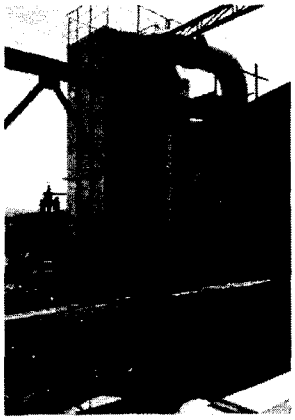

Fig.2(c) Overview of 2nd Combustion chamber in RAPID-10 system

Fig.2(d) Overview of Bag-filter in RAPID-10 system

## Test Trials of RAPID-10 System

The RAPID-10 system which has 4 Mw of the maximum electrical power of the plasma system is designed to being DC transferred plasma is directed from the cathode down to the axis of the furnace hearth containing molten product which acts as the anode. EAF dusts are feed by screw feeder through the furnace roof. Melting and reduction of raw materials occur during falling down to the hearth.

Zn and Pb metal vapor is carried over with exhausted gas and heat transfer is rapidly occurred by contacting with Pb mist in Zn condenser. Liquidifying of Zn follows afterwards.

Metallic Zn vapor is condensed and in Zn condenser and seperation of Zn and lead then followed.

Off-gas handling system, consisted of water-cooled heat exchanger, cyclone and bag filter, are operated to collect secondary dust.

## Operation of RAPID-10 system

Table 2 show the chemical composition of EAF dust used in this study. Due to the variation of the composition of EAF dust treating of EAF dust has to be simplified.

For these purposes, important parameters - such as F'ce temp. splashed Pb rate, Pb temp. etc - affected on recovery of Zn and plasma f'ce operation were fixed through test trials.

Under the base of the experience of proto-type RAPID system operation, the test trial has been carried out for finding proper operation condition and scale-up factor for designing RAPID-50 system (commercial scale).

Table 2 show the chemical composition of EAF dust used in this research.

| Element | Wt.% |
|---|---|
| $SiO_2$ | 3.77 |
| ZnO | 27.82 |
| Na | 1.53 |
| K | 2.11 |
| T.Fe | 30.33 |
| CaO | 2.82 |
| MgO | 1.02 |
| Pb | 3.43 |
| $Al_2O_3$ | 0.7 |

Fig. 4 shows the recovery of Zn from EAF dust as a results of test trial with RAPID-10 system.

In this case, Pb, Zn collecting media, was charged by 450Kg, the temperature inside Pb pot is controlled 550 C. the flow rate of nitrogen used as a plasma gas, was 7 $Nm^3/Hr$.

The recovery were fluctuated by the change of operation condition, such as feed rate, f'ce temperature, Zn condenser temperature etc. Now the recovery of Zn from EAF dust with RAPID-10 system is about 75%, and to increase the recovery of Zn, test trial and modifying of Zn-condensing parts in RAPID-10 system is carrying on.

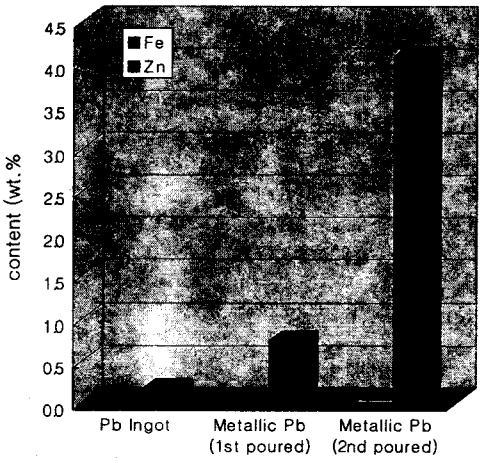


Fig. 4 Recovery of Zn in RAPID-10 System

## Properties of recovered products

Mainly 2 kinds of metal -such as Fe, Zn- are recovered from EAF dust treating with RAPID system. The iron (Table 3) recovered from EAF dust, which contains about 1.2 wt % carbon, is revealed to be classified as a bonus grade steel scrap. Results of chemical composition of Zn metal recovered from EAF dust by RAPID system are shown in Table 4.

Table 3 Typical chemical composition of recovered iron

| C | Mn | Ni | Fe |
|---|---|---|---|
| 1.21 | 0.046 | 0.23 | bal. |

Table 4 Typical chemical composition of recovered Zn

| Zn | Pb | Cu |
|---|---|---|
| 95.7 | 2.3 | 1.2 |

In Fig.5, separation of Zn and Pb is shown. The upper white layer represents metallic Zn and the lower gray layer is Pb, which has a role as a Zn collecting media. The white sphere is metallic Zn entrapped during separation.
This means that the cooling rate is rapid enough to separate the Zn and Pb by difference of density.

Fig.5. separation of Zn and Pb.

Table 5. The chemical composition of the slag

| | |
|---|---|
| $SiO_2$ | 27.4 |
| $Al_2O_3$ | 16.9 |
| ZnO | 0.006 |
| MnO | 4.88 |
| CaO | 32.75 |
| MgO | 7.26 |
| FeO | 9.7 |

The chemical compositions of the slag are shown at Table 5. A toxicity test results (Table 6), carried out by USEPA standard, donates that the safety of treated slag by RAPID System is confirmed for landfill.

Table 6. A toxicity test results

| | Cd | Pb | $Cr^{+6}$ |
|---|---|---|---|
| EAF Dust | 0.03 | 66.52 | 0.13 |
| Slag | 0.02 | 0.02 | 0.01 |
| Legal Allowance | 1 | 5 | 10 |

## Conclusion

A study to recover valuable metals, Fe, Zn, Pb and Cd from EAF dust, using the RAPID system developed by RIST combined with Zn-condenser was carried out.
The results are as follows;

1. The RAPID system is revealed to be the proper system for treating EAF dust.

2. In the RAPID-10 System pilot test, the recovery

rate was about 75 wt.%, and to increase the recovery of Zn, test trial and modifying of Zn-condensing parts in RAPID-10 system is carrying on..

3. Construction of RAPID-50 system for treating 50,000 ton of EAF dust per year is now undergoing.

## Acknowledgement

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