Available online at www.sciencedirect.com
SCIENCE DIRECT®
Int. J. Miner. Process. 75 (2005) 1–20
INTERNATIONAL JOURNAL OF MINERAL PROCESSING
www.elsevier.com/locate/ijminpro

Water leaching and magnetic separation for decreasing the chloride level and upgrading the zinc content of EAF steelmaking baghouse dusts

W.J. Bruckard[a,*], K.J. Davey[a], T. Rodopoulos[a], J.T. Woodcock[a], J. Italiano[b]

[a] CSIRO Minerals, Box 312, Clayton South, Vic. 3169, Australia
[b] Technical Development, Smorgon Steel Group Ltd., P.O. Box 1, Laverton, Vic. 3028, Australia

Abstract

Recycling scrap iron and steel in electric arc furnaces (EAFs) generates very fine metal-containing dusts which can present major environmental problems. This paper describes experimental work on a relatively novel, simple, and inexpensive process for decreasing the chloride content and upgrading the zinc level of dust from an Australian plant, to produce saleable products and environmentally safe waste products for disposal.

The dust contained about 2.1% Cl as various chlorides, 23.1% Zn as zincite and franklinite, 27.1% Fe as magnetite, franklinite, and hematite, plus small quantities of lead, cadmium, chromium, and other materials. The dust was very fine (P_{80} about 2 μm). Individual particles were commonly aggregates of fine spheres and other shapes.

Simple water washing at ambient temperatures and natural pH (12) for 60 min extracted 99% of the chlorides, giving a residue assaying 200 ppm Cl. This residue was strongly coagulated by lime present in the dust and settled rapidly. The wash solution contained low levels of iron, zinc, lead, cadmium, and chromium, most of which could be removed by sulphide precipitation.

Wet magnetic separation with a Davis tube was investigated. At the lowest field strength employed (0.6 A), 95% of the zinc was recovered in a non-magnetic product assaying 28% Zn and 24% Fe. At the highest field strength (1.6 A), 91% of the zinc was recovered in a non-magnetic product assaying 29% Zn and 25% Fe. Wet cycloning at a nominal separation size of 2–5 μm gave a cyclone overflow product assaying 31% Zn and 26% Fe, and containing 85% of the zinc. All these results fit a typical zinc grade–recovery relationship.

The proposed process of water washing followed by magnetic separation or cycloning would produce a relatively high-zinc, low-iron, low-chloride product suitable for treatment in a lead–zinc smelter or electrolytic zinc plant, a high-iron, low-zinc product suitable for land fill, and a treated waste water for discharge to a sewer.

Keywords: EAF dust; water leaching; magnetic separation; cycloning; waste management; zinc

1. Introduction

Electric arc furnace (EAF) steelmaking, as conducted by Smorgon Steel at Laverton North, Victoria (Viera, 1993), uses general steel scrap as raw

* Corresponding author. Tel.: +61-3-9545-8500; fax: +61-3-9562-8919.
E-mail address: Warren.Bruckard@csiro.au (W.J. Bruckard).

0301-7516/$ - see front matter © 2004 Elsevier B.V. All rights reserved.
doi:10.1016/j.minpro.2004.04.007

material, and is the major route for recycling steel scrap. Inevitably, scrap steel contains various contaminants such as galvanised iron, other metals and alloys, rust, plastics (e.g., from car bodies), and various types of mineral matter. In addition, during furnace operation, it is necessary to add fluxes (e.g., limestone or lime), a reductant (e.g., brown coal char), and oxygen gas. Furnace operation generates a hot (1650 °C) off-gas containing fume and particulate matter. This gas is cooled and passed through a baghouse before discharge to atmosphere. The EAF dust collected is very fine and contains base metals, especially zinc, and soluble chlorides. It is thus a toxic product, and is described as such by the United States Environment Protection Agency (EPA), and therefore presents a problem for disposal in an environmentally acceptable way. However, the relatively high zinc level (typically about 23–26% Zn) provides a potentially valuable resource, even though the zinc is present as oxide phases such as synthetic franklinite ((Zn,Fe,Mn)O.(Fe,Mn)$_2$O$_3$) and zincite (ZnO).

With the increasing world-wide use of EAFs for reclamation of scrap steel, disposal of the dust has become a major and widespread problem, and many techniques have been proposed to solve it. Pearson (1981) was one of the first authors to review the proposed and available processes, and Zunkel (1997, 2000) and Liebman (2000) have reviewed more recent developments. Stewart et al. (2000) edited a volume containing many related papers, and Sukonthanit et al. (2000) published a paper on an iron distillation process with specific relation to EAF dust from Smorgon Steel. Drinkard and Woerner (1997) have developed a nitric acid leaching process, which can be preceded by a water wash, to recover heavy metals from EAF dust. Tsai and Li (1989) studied dilute HCl leaching followed by magnetic separation of some 13 EAF dust samples from Taiwan and published some dust characterisation data. Lindblom et al. (2002) also studied acid leaching of an EAF dust from Sweden and also included dust characterisation data.

Most of the above processes were concerned with pyrometallurgical and hydrometallurgical routes to recover zinc and possibly other metals. However, they all produced other waste products that presented further waste disposal problems, and these problems tended to be overlooked. Hence, it was worth seeking a different and simpler process.

This paper describes a novel and relatively simple and robust process to lower the chloride level and upgrade the zinc content of EAF dusts to give a zinc-rich product for smelting, an iron-rich product for dumping, and a treated solution for sewer discharge.

The work involved four aspects. These were (i) basic characterisation of dust samples from Smorgon's operation, (ii) an investigation of water leaching to remove chlorides and other water-soluble salts, (iii) magnetic separation to remove a high-iron product and thereby to produce a product with an enhanced zinc grade, and (iv) hydrocyclone separation to produce a relatively fine zinc-rich product and a relatively coarse iron-rich product (both products containing particles only a few microns in size). Some combinations of these unit processes were also considered, and a suggested flowsheet is presented and discussed.

2. Experimental

Experimental work included basic sample characterisation, water leaching, and magnetic separation. In addition a small laboratory cyclone was used to make a size split on the feed material.

2.1. Samples

For some preliminary work, a 1-kg sample of EAF dust was received. This was used to obtain some general characterisation data and to conduct a preliminary water washing experiment. Apart from being slightly coarser and having a slightly higher zinc assay than the main sample noted below, its character and response to washing were very similar. This gave confidence that the results obtainable were reproducible on different samples.

The main material used was a 7-kg EAF dust sample labelled "Baghouse dust sample—Line 1 end" from Smorgon Steel's baghouse at Laverton North. This sample was dry on receipt and was brushed through a 1-mm aperture brass screen. Subsamples ranging from 5 to 250 g were riffled out for analysis and test-work.