United States
Environmental Protection
Agency

EPA/540/M5-91/005
Aug. 1991

SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

Demonstration Bulletin

Flame Reactor

Horsehead Resource Development Company, Inc.

Technology Description: The Horsehead Resource Development Company, Inc. (HRD) Flame Reactor is a patented and proven high temperature thermal process designed to safely treat industrial residues and wastes containing metals. During processing, the waste material is introduced into the hottest portion of the Flame Reactor, where the wastes are subjected to a very hot reducing gas (greater than 2000°C) produced from the combustion of solid or gaseous hydrocarbon fuels in oxygen-enriched air. At these high temperatures volatile metals in the waste are volatilized and organic compounds are destroyed. The waste materials react rapidly, producing a non-leachable slag and gases, including steam and volatile metal vapors. The metal vapors further react and cool in the combustion chamber and cooling system to produce a metal-enriched oxide that is collected in a baghouse. The resulting metal oxides can be recycled to recover the metals. The amount of waste reduction to slag and oxide depends on the chemical and physical properties of the waste material.

Nonvolatile metals are vitrified in the slag that leaves the reactor from the slag separator. After testing to ascertain that the slag is nonhazardous, it can generally be recycled as clean fill material. If the slag cannot be recycled because it is determined to be toxic after Toxicity Characteristic Leaching Procedure (TCLP) testing, it can be disposed of in a permitted landfill. Figure 1 presents a schematic diagram of the HRD Flame Reactor.

Waste Applicability: The Flame Reactor technology can potentially be applied to many types of granular solids, soil, flue dust, slag, and sludge containing very high concentrations of heavy metals. Wastes to be treated by the Flame Reactor should be dry (less than 15% total moisture) and fine-grained (less than 200 mesh) to react rapidly. Larger particles (up to 20 mesh) can be processed, but may decrease the efficiency of metals recovery or the capacity of the reactor. Wastes not meeting the moisture content and particle size criteria require pretreatment. Generally, wastes with high concentrations of heavy metals that have a significant market value (zinc, lead, arsenic, and possibly silver and gold) should enhance the overall process economics. Product metal oxide containing valuable metals can be further processed for metal recovery in industrial smelters.

Demonstration Results: The HRD Flame Reactor was demonstrated at the HRD facility in Monaca, Pennsylvania, in March 1991. Approximately 72 tons of waste material from the National Smelting and Refining site in Atlanta, Georgia, was treated during all phases of testing for the HRD SITE demonstration. This waste material is a granular secondary lead smelter blast furnace soda slag containing approximately 15.0% carbon, 10.3% iron, 12.2% sodium, 5.3% sulfur, 5.4% lead, 5% silicon, 2.5% chlorine, 0.4% zinc, 0.5% arsenic, 0.04% cadmium, many other metals and inorganic chemicals, and approximately 15% water. The

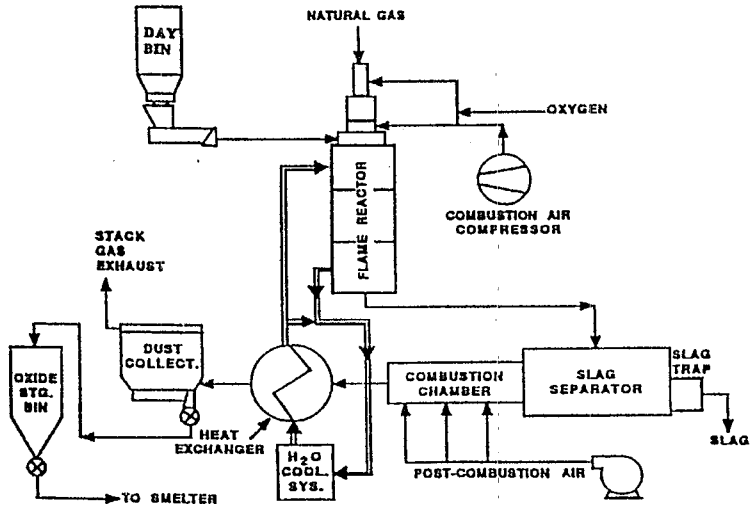

Figure 1. HRD Flame Reactor Process Flow Schematic

waste material was dried and passed through a hammermill prior to treatment in the Flame Reactor. The demonstration test runs included a series of shakedown runs to establish optimal operating conditions, a blank run during which no waste was treated, three test runs, and a series of additional runs to evaluate system durability and to process remaining waste material.

Extensive process operating data and analytical samples were collected. The operating data included raw waste feed and processed waste accumulation rates, natural gas and oxygen consumption rates, electrical consumption, temperatures throughout the system, and flow rates throughout the system. Laboratory analyses included analyses of the raw feed for metals, energy content, ash content, moisture, sulfur, chloride, fluoride, carbon, and total organic carbon content. Effluent samples (processed waste slag and baghouse dust) were analyzed for metals. The raw feed and processed waste slag were also analyzed by TCLP testing for metals. Concentrations of CO, CO_2, O_2, NO_x, SO_2, total hydrocarbons, and metals in the stack gases were also measured. Analytical data are summarized in Tables 1 and 2.

Key findings from the HRD SITE demonstration are summarized below:

- Although samples of the raw feed failed the TCLP test due to high cadmium and lead levels, all samples of processed waste slag passed the TCLP test for all metals. The processed waste slag can be disposed of in a sanitary landfill or used as fill material.
- Lead and zinc from the raw feed (5.4% and 0.4% weight) were removed from the processed waste slag (0.6 and 0.1% weight) and concentrated in the baghouse dust (18.0% and 13.2% weight). The baghouse dust may be recycled for its lead content. The process showed better than 90% recovery for both lead and zinc.
- The weight of the waste was reduced by approximately 30%, largely due to removal of water and carbon during pretreatment and treatment.
- With the exception of SO_2, stack gas emissions were within HRD permit limits. SO_2 emissions were high due to the amount of sulfur in the waste. The SO_2 emissions could readily be controlled with the use of a scrubber.

An Applications Analysis Report and a Technology Evaluation Report describing the complete HRD SITE demonstration will be available in the Spring of 1992.

Table 1. *Metal Concentration Ranges in Influent and Effluent Wastes (Preliminary)*

	Raw Feed (mg/kg)	Processed Slag (mg/kg)	Baghouse Dust (mg/kg)
Arsenic	428-582	92.1-675	1,010-1,130
Cadmium	380-512	2.3-13.5	1,080-1,370
Copper	1,460-2,590	2,730-3,890	1,380-1,670
Iron	95,600-111,000	167,000-228,000	29,100-31,800
Lead	48,200-61,700	1,560-11,400	159,000-180,000
Zinc	3,210-4,660	709-1,680	10,000-16,200

Table 2. *TCLP Results (Preliminary)*

	Raw Feed (mg/L)	Processed Slag (mg/L)
Arsenic	<0.210-0.264	<0.210-0.930
Barium	0.0177-0.0675	0.109-0.281
Cadmium	7.61-15.8	<0.050
Chromium	0.140-0.283	<0.060
Lead	4.35-6.80	<0.330
Mercury	<0.010	<0.010
Selenium	<0.030-0.160	<0.030-0.0730
Silver	<0.050	<0.050

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