

Recycling Metal Bearing Wastes through High Temperature Metal Recovery:

*Mark Schweers
INMETCO*

History and Development of the Process

The High Temperature Metal Recovery Process (HTMR) was developed by INCO to serve the specialty steel industry. In the 1970's it became apparent that landfill was an unacceptable solution for the disposal of industrial waste. There was also widespread concern about the efficient use of natural resources. Recognizing this, and as a service to its customers in the specialty steel industry, INCO developed a method for reclaiming metals from specialty steel making wastes such as electric arc furnace dust, mill scale and swarf. (Swarf is a mixture of cutting oil, water and metallic grindings and shavings from the finishing and polishing of specialty steel). The process was developed at INCO's laboratory in Sterling Forest, NY then pilot tested at the pilot testing facility in Port Colborne, Ontario. In 1978 the facility was built in Ellwood City, PA. The site, 35 miles northwest of Pittsburgh, was chosen because of its proximity to many of North America's largest specialty steel making companies.

In 1978 the facility began recycling wastes from specialty steel manufacturing, electric arc furnace dust, mill scale and swarf. These wastes still make up a large percentage of INMETCO's feedstock. However, the process feed specifications have been broadened to include a wide variety of metal bearing wastes such as: nickel-cadmium, nickel-iron and nickel metal hydride batteries; nickel and chromium sludges and cakes; nickel and chromium waste liquids and catalysts. Prior to acceptance for the process, all materials are analyzed or "pre-screened." The materials are assayed for elements and compounds that contribute to the process: nickel and chromium; and for elements and compounds that if they are present in high concentrations, may upset the process, for example: phosphorus, copper and tin.

Approximate Solid Waste Feed Specifications (in % dry wt basis)

nickel	greater than 1.3
chromium	greater than 5.0
copper	less than 2.0
phosphorus	less than 0.05
tin	less than 0.03

Approximate Liquid Waste Feed Specifications (in mg/L)

nickel	greater than 100
chromium	greater than 10
copper	less than 1,800
phosphorus	less than 860
tin	less than 400

Process Description

The HTMR process has three basic steps: 1. Feed Preparation 2. Reduction 3. Smelting and Casting. In the feed preparation phase, both solid and liquid wastes are drawn from storage containers and blended with other additives to form pellets for further processing. Coke, coal or wastes carbon products which are used as reduction agents, are mixed in at this point. A screw conveyer mixes and transports the resulting mixture to a pelletizing disk. Here liquids such as

waste nickel and chromium solutions generated by the electroplating industry and waste pickling acids generated by the steel industry are added to form “green” pellets.

The green pellets are transferred to a Rotary Hearth Furnace (RHF) operating at 2,300 degrees Fahrenheit. In the furnace, some of the carbon added during blending reacts with the oxygen in the wastes to reduce the metal bearing wastes to their metallic form. Gas produced in the process is discharged to a wet scrubber system. The off-gas system water is then sent to a wastewater treatment plant. This water is recycled back to the plant for re-use. All that is released to the atmosphere is water vapor along with the usual products of combustion.

The hot reduced feed from the RHF is combined with other material and transferred to the Electric Arc Furnace (EAF) where the third major process occurs. The RHF performs a smelting operation to produce a nickel, chromium and iron alloy. Lime, silica, alumina, and magnesia separate to form a slag and metal bath. Metal and slag are tapped periodically from the furnace. The ratio of slag to metal is about one and a half parts slag for every two parts of metal produced. The slag is collected and hauled to a slag cooling area. This non-hazardous co-product will be further processed, sized and sold for use in building roads, parking lots and commercial driveways.

Casting is the final step. Molten metal is cast into pigs using a Twin Strand Pig Caster. When processing nickel, chromium, and iron bearing wastes, a remelt pig is produced with a typical composition of 8% to 16% nickel and 9% to 16% chromium, the balance of the pig is essentially iron with minor amounts of manganese, molybdenum, and carbon.

Remelt Alloy	
Specification (in %)	
nickel	8-16
chromium	9-16
iron	balance

Cadmium Recovery

In 1996 a cadmium recovery facility was added to the process to provide recycling services to the nickel cadmium battery industry. The facility processes both large, industrial cells that are used by railroads, in aircraft and by electric utilities; and dry or consumer type cells that are used to power portable tools, computers and telephones.

The industrial cells are drained. The cells are dismantled using a large band saw to cut the tops off the batteries, allowing the nickel and cadmium plates to be separated. The cadmium plates are placed in the cadmium recovery furnace. Cadmium is reduced using carbon, vaporized and condensed with a water spray. This produces 99.95% to 99.99% pure cadmium in the form of cadmium shot. The cadmium reclaimed from this operation is returned to nickel-cadmium battery manufacturers. The nickel containing plates from the industrial cells become feedstock for the EAF in the metal recovery plant.

Dry or consumer type nickel-cadmium battery packs are placed in a natural gas fired thermal oxidizer where plastic, paper and electrolyte gel are vaporized, leaving clean nickel-cadmium battery cells. Gases from the thermal oxidizer are sent to the RHF where they are thermally consumed with any particulate in the off gas. The clean nickel-cadmium batteries are placed in the cadmium recovery furnace. Cadmium is reduced using carbon, vaporized and condensed with a water spray. This produces 99.95% to 99.99% pure cadmium in the form of cadmium shot. The cadmium reclaimed from this operation is returned to nickel-cadmium battery manufacturers. The nickel substrate and steel can from the consumer cells become feedstock for the EAF in the metal recovery plant.

Summary

High Temperature Metal Recovery (HTMR) produces efficient recovery rates (98% nickel -- 86% chromium -- 96% iron), provides complete reclamation of all components of a waste and produces a product for direct re-use by the specialty steel industry. In addition, HTMR is recognized by US EPA as the Best Demonstrated Technology (BDAT) for metal bearing wastes generated by the specialty steel industry and for nickel-cadmium batteries. The paper focused on the steps of the HTMR process: 1. Feed Preparation 2. Reduction 3. Smelting and Casting. Also the criteria used for waste feedstock evaluation and the recovery of metal and non-metal components of wastes were considered.