ARCFUME: METAL RECYCLING AND DEEP-CLEANING OF SLAGS

Bror-Magnus HEEGAARD, Maria SWARTLING

SCANARC Plasma Technologies AB, PO Box 41, 813 21, Hofors, Sweden

bror.magnus.heegaard@scanarc.se

Introduction

Every year large volumes of metal containing residues are generated and landfill disposal is still a common way to manage these residues. However, environmental constraints of today make it more difficult and expensive to continue this landfill process. Therefore, it is of great interest to investigate ways of reprocessing these residues; it would save landfill costs, create an additional income from the recovered metals and save resources for future generations.

ScanArc ARCFUME submerged plasma technology has a demonstrated capability for processing commercial hazardous and non-hazardous residuals and to recover the contained values. The process is very flexible and provides a wide range of options when designing a metallurgical process, making it one of the best choices for selective extraction of metals.

This paper presents the concept of ARCFUME submerged plasma furnace, with emphasis on applications of metal recycling and deep-cleaning of industrial residues.

ScanArc has a long history of developing applications of plasma technology and design of metallurgical processes. In Hofors, Sweden, ScanArc operates a pilot scale ARCFUME plant for development and demonstration purposes. During the last years, ScanArc has carried out several development projects in cooperation with European companies and universities, mostly focused on residuals from the non-ferrous industry. Typically, such projects do not only focus on the metallurgical part, however a growing focus is the valorisation of slag, a major part of most pyro metallurgical installation.

ARCFUME Technology

The ARCFUME process is a submerged plasma process. The principle behind the technology is that electricity is used to provide heat for melting, reduction and evaporation of elements. Carbon is added only for reduction purposes to enable requested chemical reactions. By not using a combustion reaction to provide heat, temperature and oxygen potential is decoupled allowing selective recovery of elements. The ARCFUME process is a very flexible process and provides a wide range of options when designing a metallurgical process. Below a brief introduction to plasma technology is given, followed by a description of the ARCFUME process.

Plasma technology

A plasma generator is a device for transforming electric energy into heat energy carried by a gas, see schematic picture in Figure 1. Inside the plasma torches blast air is transformed into a high-enthalpy plasma gas. Due to the high enthalpy of the plasma forming gas less gas is needed to supply the same amount of energy to the process compared to a conventional burner. The gas is injected in the molten bath leading to a good mixing and hence excellent heat transfer. The arc itself may carry temperatures up to 20000°C while the gas injected to the bath carries an average temperature within the interval 3000-5000°C.

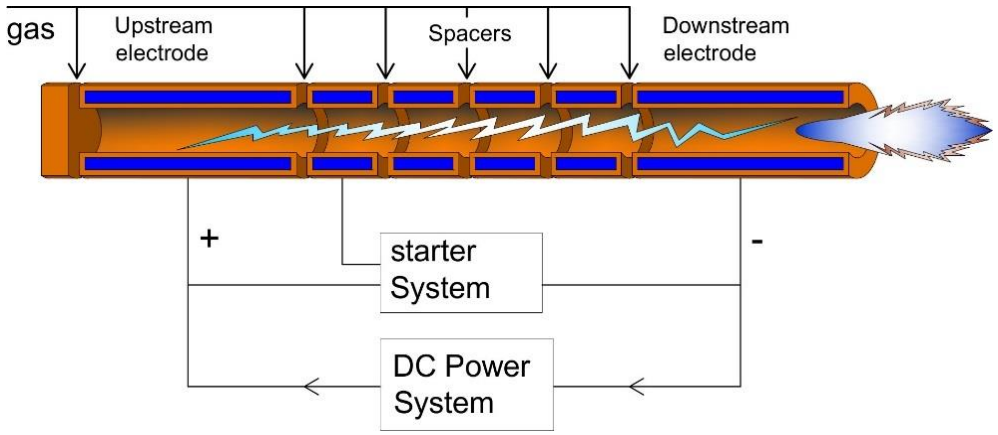

Figure 1: Schematic figure of a plasma generator

ARCFUME reactor

Figure 2 is a schematic figure of the ARCFUME reactor. Under the slag level, submerged plasma generators are connected *via* water cooled tuyeres. Injection of high temperature gas under high pressure creates a vigorously foaming slag, which provides for a high bath agitation. Due to the high temperature and heavy stirring of the slag bath chemical reactions reach equilibrium almost instantly. At the slag level and above the reactor is water cooled. The water cooling creates a lining of frozen slag on the inside of the furnace. The freeze lining protects the reactor from aggressive slag chemistry, high thermal loads and mechanical wear.

Feed preparation

ARCFUME can handle large variations in feed quality and characteristics: physically and chemically. Raw material is premixed with a reducing agent, slag formers and other additives and carbon is added only for reduction purposes to enable requested chemical reactions. The premixed material is transported to the furnace where it is continuously fed and drops directly to the turbulent slag bath. If the raw material is dusty, agglomeration as pellets or briquettes is preferred to avoid carry-over. If the material has high water content it should be dried, as a wet raw material results in a less energy efficient process. Hence, the water content should be balanced between minimal dusting and higher energy efficiency.

Metal recovery and deep-cleaning of slags

The ARCFUME can process large variations in feed materials. Commercial and industrial residues inputs may include EAF dust from low alloy steelmaking, leach residues from zinc industry (for example zinc ferrite precipitate from acid leach), pyrite cinder from sulphuric acid plants, Cu/Zn slag from converter units or batteries.

The strength of using plasma heated gas to provide energy to the process is the decoupling of energy input and oxygen potential; it enables processing at required oxygen potential at a wide temperature interval. A specific advantage is the possibility to operate at low oxygen potential at high temperatures. Injecting plasma heated gas to the slag bath creates a very strong agitation. The good mixing conditions make it possible to work close to equilibrium and enable very good conditions for fuming and forming a metal or matte phase. The operating temperature is controlled by the energy supply to the plasma generator.

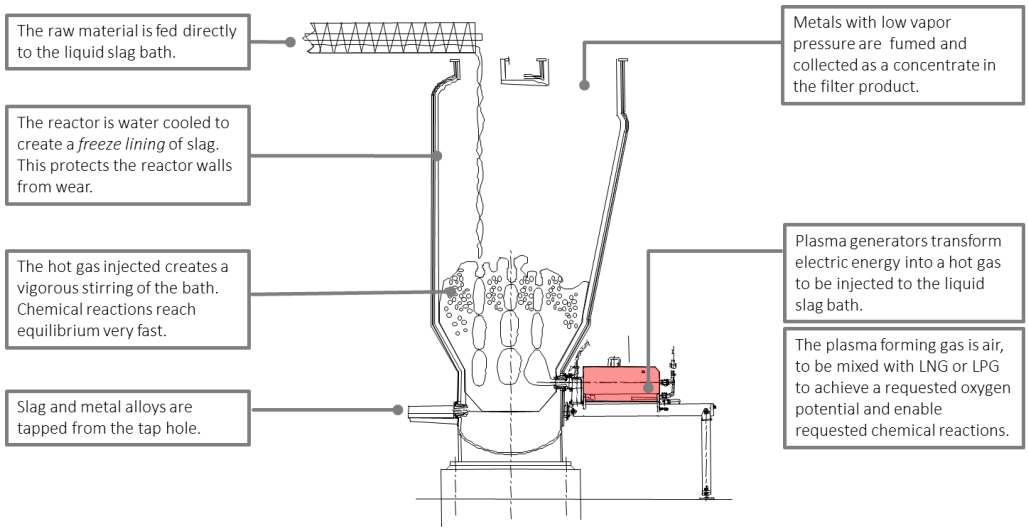

Figure 2: Schematic figure of ARCFUME reactor with key features

The oxygen potential is controlled by the air/PG (NG) flow rates ratio in the gas injected and the amount of reducing agent in the material mix. During the operation of the process, the oxygen potential can be instantly controlled by changing the air/LPG ratio. The process can therefore be designed to operate under oxygen potential and temperature conditions favourable for required reactions and selectively extract metals:

- Fuming of elements with high vapor pressure as zinc, lead, germanium, indium *etc.* These elements follow the off gases and report to an off-gas filter.
- Matte or metal formation for recovery of nickel, cobalt and copper and other precious metals.
- Avoid production of metallic iron that would dilute the metal or matte phase.
- Iron and other gangue in the feed, as silica and limestone fluxes, forms a vitreous silicate slag.

The strong agitation of the slag masses in the furnace creates large metal droplets that by gravitation falls to the bottom of the furnace facilitating the deep cleaned slag - a mineral product.

Typical metal deportment to slag, metal/matte and fumes are shown in Table 1 and are based on experience and test-work undertaken by ScanArc. Metal and matte phases act as good collectors of metals like gold, silver and other precious metals that might be present in the raw material in very low concentrations.

Table 1: Metal deportment to process products (indicative %)

	Zn	Pb	Cu	Ni	Co	Cd	Ag	Au	In	Ge	Ga
Fume product	98	99	>5	<10	<10	100	60	No data	~80	87	<5
Metal/ Matte	<1	<1	65+	~70	~50		40	75+	<10	<1	
Metallurgical slag	<1	0.03	<30	<25	<50		>5	No data	<15	<15	~95

Handling of products

Slag is tapped from the furnace into ladles and crushed, or directly granulated. Metal or matte is tapped periodically in ladles, cooled to ambient temperature, emptied and manually separated from slag.

Fumed particles, as zinc and lead oxides, are carried by the off-gas through to the gas cooling system. It continues into a bag filter from where the dust is collected and recovered as a filter product. Since low gas volume is needed for energy supply also the off-gas volumes are smaller compared to a conventional process, which enables smaller downstream off gas treatment and production of more concentrated gases.

Conclusions

The paper has presented the ARCFUME submerged plasma technology for treatment of metal containing commercial and industrial residuals. While many conventional methods result in residual material for disposal, a plasma furnace provides value-added products that include metal oxides, metal or matte and a deep-cleaned slag. Of significance is the ability to process residuals without a final need to dispose of any residual hazardous materials; all the products are potentially useable.

During the last years, ScanArc has carried out several development projects in cooperation with European companies and universities–all with the ambition to contribute to a sustainable industry. ScanArc will continue these collaborations and promote our technology as basis for European smelters to compete on the world stage by increasing overall yield and create opportunities to added values from mineral products.