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1. Summary

The PLASMASMELT process for crude iron has a modification, PLASMADUST, for treatment of all types of zinc-bearing oxidic materials, not only conventional but also low-grade and complex materials, primary as well as secondary. Without previous sintering the fine material is injected with coal powder into a plasma-heated furnace where liquied and gaseous metals are formed.

As no air is blown into the furnace, the gas volume is small which facilitates the condensation of zinc vapor and simplifies the total construction. Also other base metals in the raw material are recovered.

As the heat losses are small, the utilization of electrical energy is efficient, and the production costs are well competitive with conventional methods. Because of the simple equipment required, the specific investment is low.

2. Background

From a global point of view there exists a considerable reserve of zinc ore in the so called fine-grained complex sulphide deposits which, however, can not be utilized with the metallurgical technology available today. Furthermore, there are large quantities of low-grade zinc materials, both primary such as oxidic ores and secondary such as slags and leach residues which are considered to be economically submarginal.

All existing methods for the treatment of these low-grade materials are based on the fuming principle, i.e. the material is submitted to a reduction whereby momentarily zinc vapor is formed although at very low partial pressure and this vapor is immediately taken to a part of the equipment where oxidizing conditions prevail, and here the vapor is oxidized to a fume of zinc oxide. This fume is collected as a fine dust. In order to be utilized it must be reduced once again in order to form a dense zinc vapor which can be condensed to liquid zinc.

It is the cost of this so to say double reduction which is prohibitive for the economic utilization of these low grade materials. If the zinc in the first vapor could be condensed, there could be a possibility to apply a cheaper treatment.

3. The PLASMASMELT process

Recently the PLASMASMELT process for crude iron has been developed, and a modification of this, the PLASMADUST process, has proved itself capable to attain a single reduction for liquid zinc production. The latter will first briefly be presented, fig. 1.

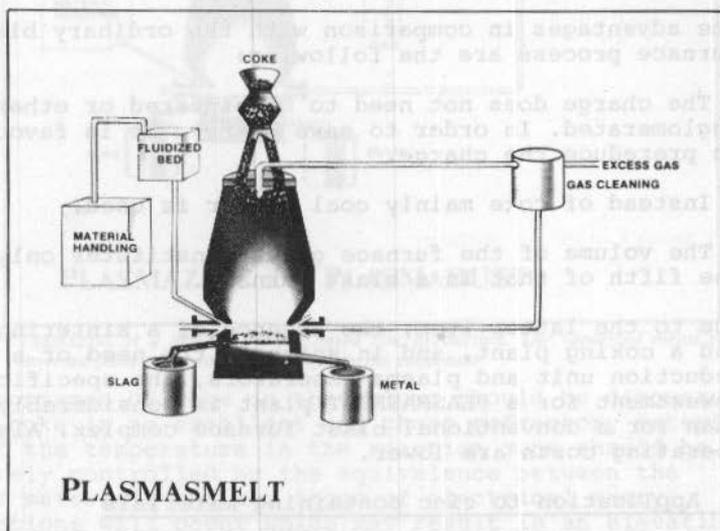


Fig 1 The PLASMASMELT process requires no coke or sintering plant making it very compact. Investment costs are also lower.

Into the tuyere level of a low shaft furnace pre-reduced iron ore concentrate and coal powder are injected together with a small quantity of a very hot gas which carries between 4 and 8 kWh/Nm³. The preheating to about 3500°C is performed by passing the gas through an electric arc in a so-called plasma generator. The shaft is filled with coke, and in the lower part of the coke column a cavity is formed in which the endothermic reaction between oxide and reducing agent (85% coal, 15% coke) occurs. As there is no admission of air or other free oxygen, all heat required for the reaction emanates from the plasma gas which forms a small part of the exit gas.

In presence of excess coke only carbon monoxide and hydrogen (from the coal) are formed; these gases rise in the shaft, and as their volume is small, most of the suspended particles are caught on the coke surface and eventually return to the reaction zone. The gases are used for pre-reduction of the ore concentrate.

At the bottom of the shaft crude iron and slag are separated and tapped in the usual way.

The advantages in comparison with the ordinary blast furnace process are the following:

- The charge does not need to be sintered or otherwise agglomerated. In order to save energy, it is favourable to prereduce the charge.
- Instead of coke mainly coal powder is used.
- The volume of the furnace gases constitutes only about one fifth of that in a blast furnace.

Due to the latter item, the absence of a sintering plant and a coking plant, and in spite of the need of a pre-reduction unit and plasma generators, the specific investment for a PLASMAMELT plant is considerably lower than for a conventional blast furnace complex. Also the operating costs are lower.

4. Application to zinc containing materials

If the oxidic feed to a plasma-heated shaft furnace contains zinc oxide, this is reduced to zinc vapor which rises with the furnace gases in the hot shaft, and when cooled in a condenser, liquid zinc is formed. Also with a low content of zinc in the charge the condensation is efficient as there is no carbon dioxide or water vapor present so there is no reoxidation risk. As in the genuine PLASMAMELT process, crude iron and slag can be tapped from the bottom of the furnace. See Fig. 2.

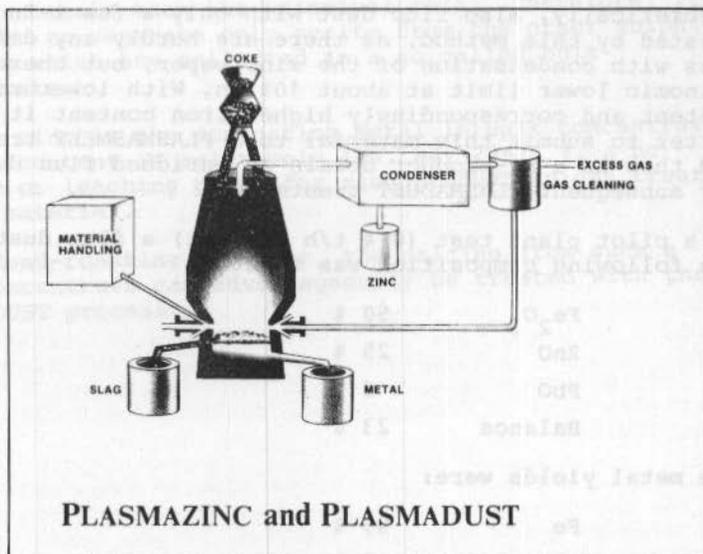


Fig 2 *PLASMAZINC is a process for ore based zinc production. The vaporized metal is converted from a gas to a liquid form in the condenser.*

The importance of coke in the column should be discussed. First, coke is an excellent and cheap refractory material. Even if the temperature in the reaction zone should be accurately controlled by the equivalence between the feed of materials and the input of electrical energy, fluctuations will occur which may result in an elevation of the temperature. The excess heat is absorbed by the coke and thus the temperature variation is smoothened. Secondly, the coke acts as a good collector of flue particles and the collected material either melts or is eventually, when the coke is slowly consumed, brought back into the reaction zone. Thirdly, carbon dioxide and water vapor are eliminated by reaction with the coke and thus the reoxidation of zinc vapor deterred.

5. Practical application

Some potential areas of application:

5.1 Steel furnace flue dust

All steel furnaces generate flue dust, in which volatile elements are enriched. This is specially valid for zinc and lead which come into the steel furnace with galvanized scrap. By melting of such scrap a dust with 20-30% Zn and around 5% Pb can be collected, and this forms a very suitable feed material for a plasma furnace treatment as just described, especially as the zinc and lead recovered can carry a considerable part of the treatment costs.

Theoretically, also flue dust with only a few % Zn can be treated by this method, as there are hardly any difficulties with condensation of the zinc vapor, but there is an economic lower limit at about 10% Zn. With lower zinc content and correspondingly higher iron content it appears better to submit this material to a PLASMAMELT treatment and thus as a by-product obtain an enriched flue dust for subsequent PLASMADUST treatment.

In a pilot plant test (0.4 t/h of dust) a flue dust of the following composition was treated:

Fe ₂ O ₃	50 %
ZnO	25 %
PbO	2 %
Balance	23 %

The metal yields were:

Fe	99 %
Zn	> 97 %
Pb	> 97 %

It can be mentioned in this connection that also flue dust from production of high-alloyed steel such as stainless steel can favourably be treated for the recovery of the alloying metals like nickel, chromium and molybdenum, as a mixed ferro-alloy. Zinc, lead and other volatile metals are eliminated and can be collected in an enriched flue dust as described above.

5.2 Slags and other residual products

Slags from lead shaft furnaces (in some cases treated in slag fuming plants) have usually a content of 10-15% zinc and 1-2% lead. There are also residues from zinc leaching plants with 10-15% Zn and some lead and silver. By treating such materials by the PLASMADUST method the valuable metals can directly be recovered in the metallic state thus making this method superior to slag fuming.

5.3 Complex minerals

A typical complex sulphide deposit may contain 0.1-3 % Cu, 0.3-3 % Pb, 0.2-10 % Zn, 20-50 % S and some minor quantities of silver and gold. These minerals are often very fine-grained and if conventional concentrates can be produced by milling and flotation, the recoveries suffer from the market's demand of relatively low assays

of other metals than the principal metal. Therefore, it is better to separate only pyrite from the other sulphide minerals which are collected in a so called bulk concentrate.

Usually zinc is the dominating metal in bulk concentrates, but the content is relatively low, say 20-25 %, a no smelter or leaching plant for zinc production can treat such a material.

After dead-roasting, however, the calcine from such a bulk concentrate can advantageously be treated with the PLASMADUST process.

