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Reduction of EAF dust emissions by injecting it into the furnace

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Filter dust arising during the electric steelmaking process causes economical and environmental problems due to its zinc and lead contents. At Det Danske Stålvalseværk A/S it has been shown that recycling the filter dust by injecting it into the electric arc furnace considerably reduces the total amount of dust. Most of the zinc in the injected dust returns to the dust fraction in the furnace atmosphere whereas the rest dissolves in the slag. The zinc accumulates in the EAF filter dust which therefore becomes more attractive for metal recovery.

No negative effect on dust emissions or steel quality resulting from the injection operation has been observed.

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Background. *The wide range of different dust fractions* arising during the steelmaking process is problematic for most steel makers on account of environmental legislation.

The fractions contain, to a very high extent, the same chemical and geological compounds as are found in the primary and secondary slag.

Depending on metallurgical and production-related conditions, it is therefore possible to recycle some of these fractions as slag additives dissolved in the slag. The slag can be economically used for a number of purposes, e.g. in road construction. In this way disposal costs can be considerably reduced.

Det Danske Stålvalseværk A/S (DDS) has recently finished an investigation on the recycling of filter dust from the scrap melting process in the electric arc furnace (EAF). This work was part of an EU-supported project in which DDS participated together with Krupp Edelstahlprofile and Forschungsgemeinschaft Eisenhüttenschlacken.

Production and plant facilities. Det Danske Stålvalseværk A/S is the only steel plant in Denmark and is situated on the Roskilde Fjord close to the city of Frederiksværk. The company has an environmental permission to produce 750 000 t/year of scrap and pig iron based steel products under strict environmental regulations. The melting facilities consist of two 110 t *electric arc furnaces* (AC), **figure 1.**

The flue gases from the two furnaces are mixed immediately after the combustion chambers and conducted to a bag filter with a flow rate of up to 150 000 m^3 (s.t.p.)/h. Under normal production conditions the filter collects about 8 000 t/year of zinc and lead-containing dusts.

The dust from the *melt shop ventilation* and local dust separators is led through a second bag filter which has a capacity of 900 000 m^3 (s.t.p.)/h and collects about 1 500 t/year of dust with low zinc and lead contents. These dust fractions are mixed and pelletized, and at regular intervals shipped for zinc and lead recovery.

Dust transfer and injection procedure. Based on investigations on the metallurgy of steel and slag as well as observations of the dust and zinc in the flue gas during short production periods with and without the injection of dust, it was decided that the filter dust be recycled in only one furnace and the dust for the recycling be collected in the hoppers of the furnace filters.

Figure 2 shows the *injection installation.* It consists of two silos, one for filter dust and one for coal dust, and two injection machines, one for the production of foaming slag and the other one for the injection of the filter and carbon dust mix.

The operation procedure is as follows: The dust arising in the filter installation is automatically drawn off and pneumatically transferred over a distance of 150 m into the filter dust silo. The carbon is extracted from a large external silo and also pneumatically transferred over a distance of 80 m into the carbon silo. Both materials are mixed and then injected. The injection machine is equipped with a dosing system ensuring the reliable transfer of the difficult to transfer dust in all weather conditions.

The two storage bins are equipped with adjustable discharging systems, enabling the preparation of exact dust/carbon mixtures. The carbon bin features a separate discharge used for providing coal dust for the production of foaming slag.

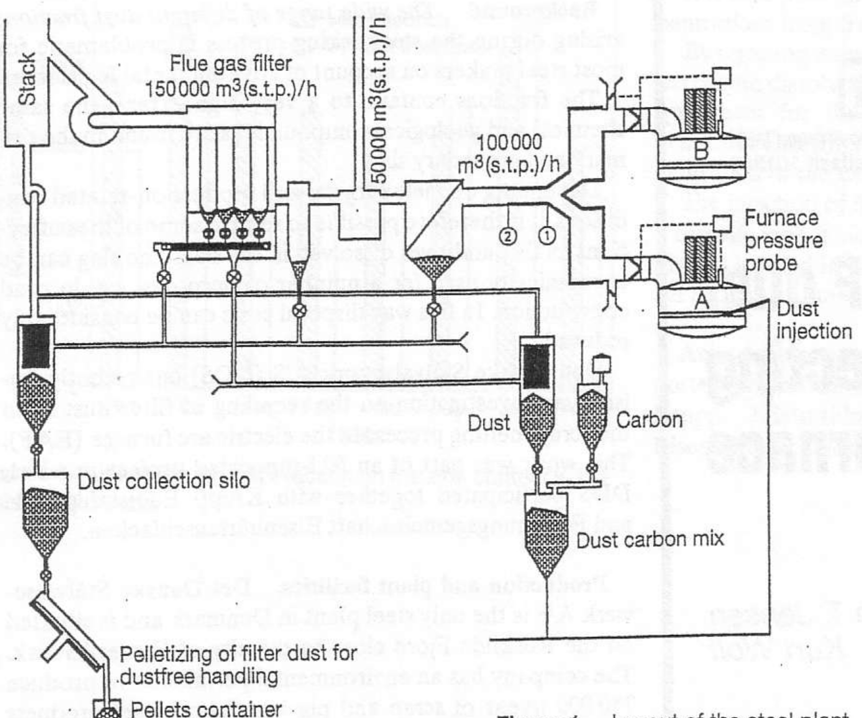

Figure 1. Layout of the steel plant

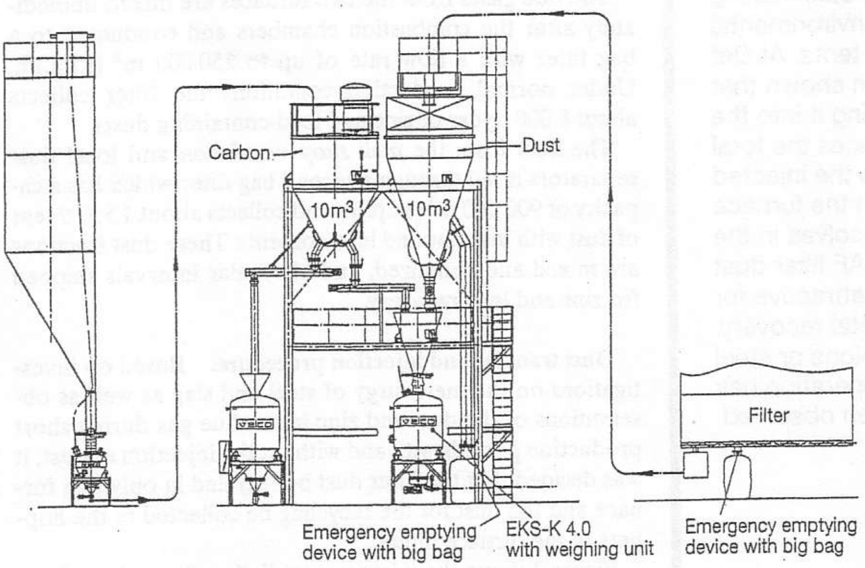

Figure 2. Equipment for the injection of filter dust

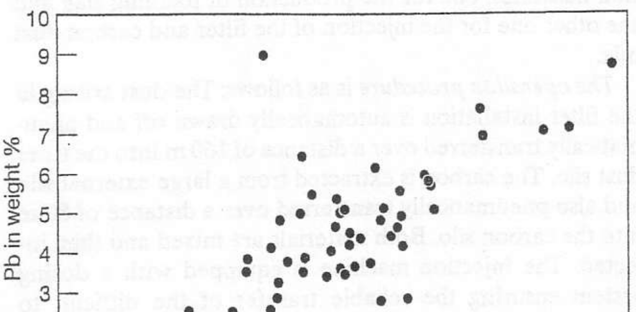

Figure 3. Relationship between lead and zinc in the filter dust

As the injection installation is equipped with a weighing system, all injected products can be precisely weighed, recorded and balanced.

The whole installation is operated from the furnace main station.

The mixing of the dust with carbon is to optimize the transfer behaviour and to provide the necessary agent to reduce metal oxides.

This dust/carbon mixture is injected into the steel/slag system in the electric arc furnace by means of dry compressed air and a ceramic-coated lance controlled by a manipulator.

Nature of the dust from scrap melting in an EAF. **Table 1,** shows a typical analysis of dust from scrap melting at Det Danske Stålvalseværk A/S.

X-ray analyses have shown that the zinc part of the dust is present as franklinite $(ZnO)(Fe_2O_3)$ and zincite (ZnO).

The grain size analysis has shown that 75% of the collected dust is under 5 µm.

Metallurgical observations. The preliminary tests have provided the following results: Practically *the total amount of zinc* entering the furnace with the scrap charge is transferred to the dust fraction of the flue gas.

The concentration of zinc in the dust varies from 10 to 80% during a heat, indicating that there are periods with dust consisting of pure zinc oxide.

There was a remarkable *relationship between the zinc and lead content* in the flue gas dust, indicating that scrap grades containing zinc are also sources of lead, **figure 3.**

The injection of dust fractions with increasing zinc contents had significant influence on the *slag analysis*, but not on the steel analysis. The mass balance showed that over 97% of the injected zinc returned to the flue gas dust.

The injection of dust fractions resulted in an *increase of iron oxide in the slag*, indicating that the non-volatile part of the dust had been dissolved.

It was observed that during injection the increase of the zinc content in the dust corresponded to that of the *flue gas temperature*, indicating that zinc vapours were oxidizing in the furnace atmosphere, **figure 4.**

Table 1. Analysis of dust from scrap melting

Analysis in weight %							
Zn	Pb	Fe_2O_3	MnO	CaO	MgO	SiO_2	Na_2O, K_2O
28	4	30	6	8	3	4	2.5

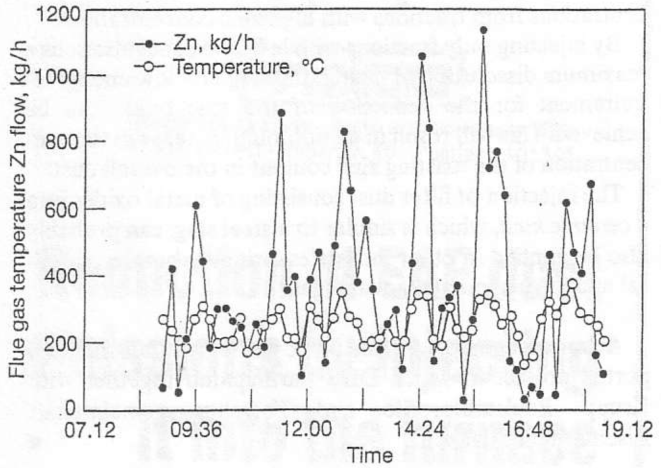

Figure 4. Relationship between the variation of the zinc content and the flue gas temperature

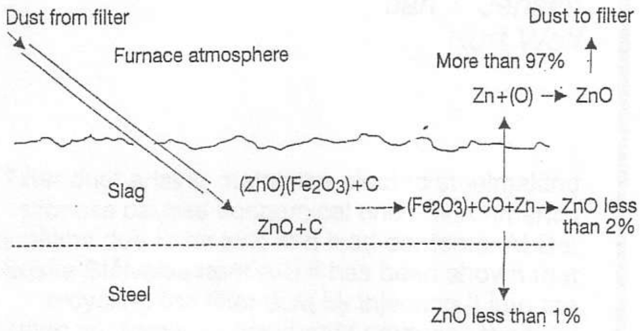

Figure 5. Mass flow of the zinc from the injected dust

These observations can be explained by the following *mass flow model* for injected dust at melt temperatures around 1 600 °C, **figure 5:**

The zinc compounds enter the slag/steel system and are reduced by the carbon to metallic zinc under heat absorption. The metallic zinc immediately vaporizes into the furnace atmosphere where the zinc vapours react with oxygen to zinc oxide under the generation of heat. The zinc oxide forms part of the dust in the flue gas. The rest of the dust, except for minor amounts of other volatile compounds, dissolves in the furnace slag.

This means that the higher the content of zinc compounds in the injected dust, the higher the energy requirement for the transfer of zinc from dust to dust.

Theoretical calculations show that over 50% of the energy needed for the treatment of a dust fraction of the composition as shown in table 1 is used for the reduction of zinc.

Operational results. During the long-term trial the *total amount of dust* from the steelmaking process and the *amount of dust* injected were registered on a monthly basis.

Starting in January 1996 the zinc content in the finished products was also calculated every month. During the trial period samples of the dust were taken before shipment and analysed for their zinc content.

Figure 6 shows the decrease in *total dust* as a function of the injected dust. It clearly shows that a large part of the non-reduced components in the dust is absorbed in the furnace slag.

Figure 7 shows the increase in *zinc concentration* in the total dust as a function of the injected dust. It clearly shows that the model for zinc transfer into the furnace atmosphere does work.

Figure 8 shows the *average monthly zinc contents* in the finished products from furnace A with dust injection and furnace B without dust injection. The steel products from the furnace with injection statistically have a higher zinc content than the products from the other furnace. However, seen in relation to the variations in the zinc content of the scrap, its influence is of minor importance. The relative difference of up to 20 ppm did not have any negative influence on the steel quality.

During the long-term trial the dust emission from the filter was continuously measured. No increase above the normal 1 mg/m³ (s.t.p.) was observed.

Conclusion. Although the overall amount of dust strongly varies from month to month, it was possible to show that the *total amount of dust* from scrap melting in the electric arc furnace can be considerably reduced by injection of dust into the steel/slag system of the furnace.

It could also be shown that metals which are volatile at steelmaking temperature return to the dust fraction under the consumption of heat, thus increasing the *concentration of the volatile metals* in the residual dust.

The process as carried out at Det Danske Stålvalseværk A/S can be *further optimized* by subdividing the total dust into individual fractions.

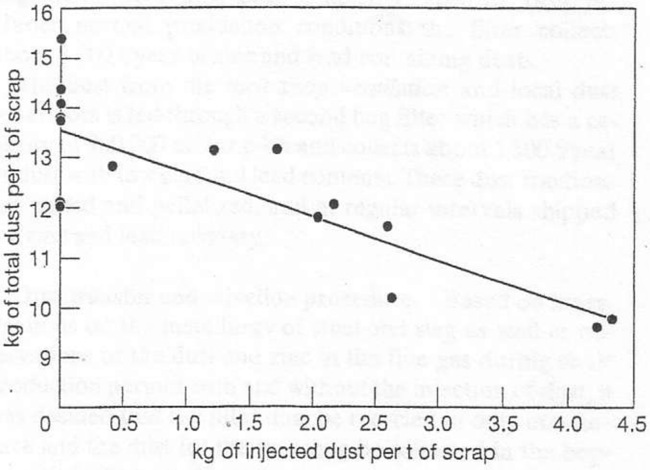

Figure 6. Relationship between total and injected dust

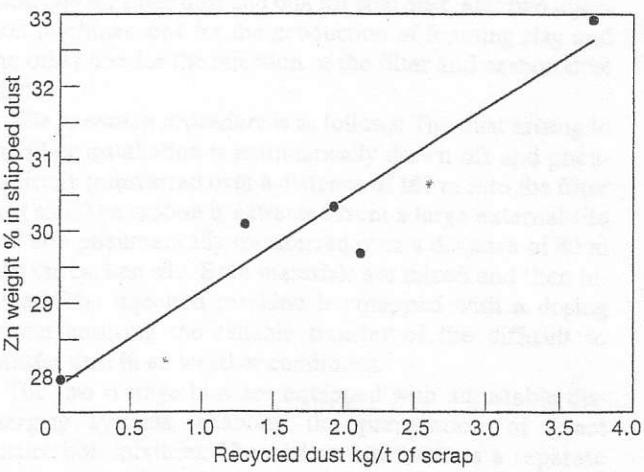

Figure 7. Relationship between the zinc concentration in the shipped and the injected dust

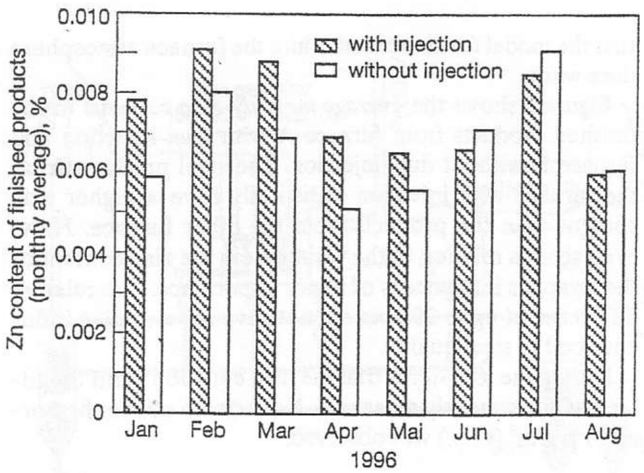

Figure 8. Influence of dust injection on the zinc content in the finished products

It is thus possible to *separate fractions* with low zinc concentrations from fractions with high zinc concentrations.

By injecting only fractions with low zinc concentrations a maximum dissolution of dust in the slag and low energy requirement for the reduction of the zinc oxide can be achieved. This will result in an optimum increase in the concentration of the existing zinc content in the overall dust.

The injection of filter dust consisting of metal oxides into a *ceramic melt*, which is similar to a steel slag, can probably also be applied in other industries, bringing both economical and environmental advantages.

Acknowledgement. This work was part of an EU-supported project in which DDS participated together with Krupp Edelstahlprofile and Forschungsgemeinschaft Eisenhüttenschlacken. ■