SOURCES OF POLLUTION IN SIDERURGY AND TECHNIQUES FOR REDUCING NOXIOUS EMISSIONS

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Abstract: The systematic identification of the various sources of pollution creates the necessary background for organizing actions in order to prevent and fight against pollution. The diversity of the sources and forms of pollution are characteristic of industrial activities, especially of those in the chemical industry, metallurgical engineering, transportation industry, generally, industrial sectors dealing with raw material manufacturing.

In the metallurgical industry, the air pollution takes place especially on the basis of the following categories of polluting agents: solid particles resulted from powders, particles drawn by combustion gases, particles of coal, ore, coke and fusing agents, slag, iron oxides, sulphur oxides (SO_2 and SO_3), nitrogen oxides (NO_2 and NO_3) and, although in smaller quantities, by tars, hydrocarbons, soot, organic acids and others.

Being familiar with the sources of pollution, their monitoring and control represent a first step towards reducing the quantity and the toxicity of all emissions, focusing on applying a "cleaner" production in the industry of elaborating and processing metallic materials, too.

This paper succinctly presents the main sources of pollution in the primary siderurgical sectors, as well as a series of techniques to reduce pollution, especially in the process of steel elaboration.

Keywords: *pollution, noxious emissions, siderurgy*

1. Introduction

During the period between1950 and 1960, steel industry represented a major source of pollution, especially air pollution. The problem of reducing air pollution was raised at once, which made the specialists focus their attention, initially, on modernizing the installations for gases and dust collection, but this approach was replaced by the introduction of new installations designed according to the concept of "cleaner" production. A "cleaner" technology is based on less polluting production procedures or procedures which use recycling technologies, reintroducing in the manufacturing process the waste material resulted from a certain technological phase, or procedures which revaluate waste material turning it into raw material for a secondary production. In a less polluting procedure, investments become productive and the expenses implied by decontamination are an integral part of the manufacturing process.

From the economical point of view, "clean" technologies, by fighting against wasting, allow achieving important energy and raw material savings, which lead to cutting down the terms for recovering the investment expenses.

2. Sources of pollution and techniques for reducing pollution in the primary siderurgical sectors.

In coking plants, agglomeration and elaboration sectors (cast iron-steel), air pollution is the most important environmental problem and diminishing or completely eradicating noxious emissions in the atmosphere is connected with the preservation of energy and resources available (fig.1).

Thus, residual gases represent a valuable source of fuel, at the same time being an important link in the energetic chain of a plant.

In the case of coking plants, the noxious emissions in the air consist mainly in powders resulted from coal supplying, coal processing and coke sorting. Burnt gases from coking batteries, coke quenching and cooling are also released in the air. Generally, before being used, the resulted gases are carried through different cleaning systems, the residual water resulted containing solid particles, heavy metals (in the case of furnace gas and converter gas cleaning) or organic polluting agents (cyanides, ammonia and others) in the case of coking gas cleaning. Besides, powders and silt containing iron can also be collected. Thus, by reducing the emissions of secondary gases in atmosphere, an ironworks can benefit from the existence of a collected power source, reducing the other expenditures, and as a result of recycling materials containing iron, the consumption of the available resources is diminished.

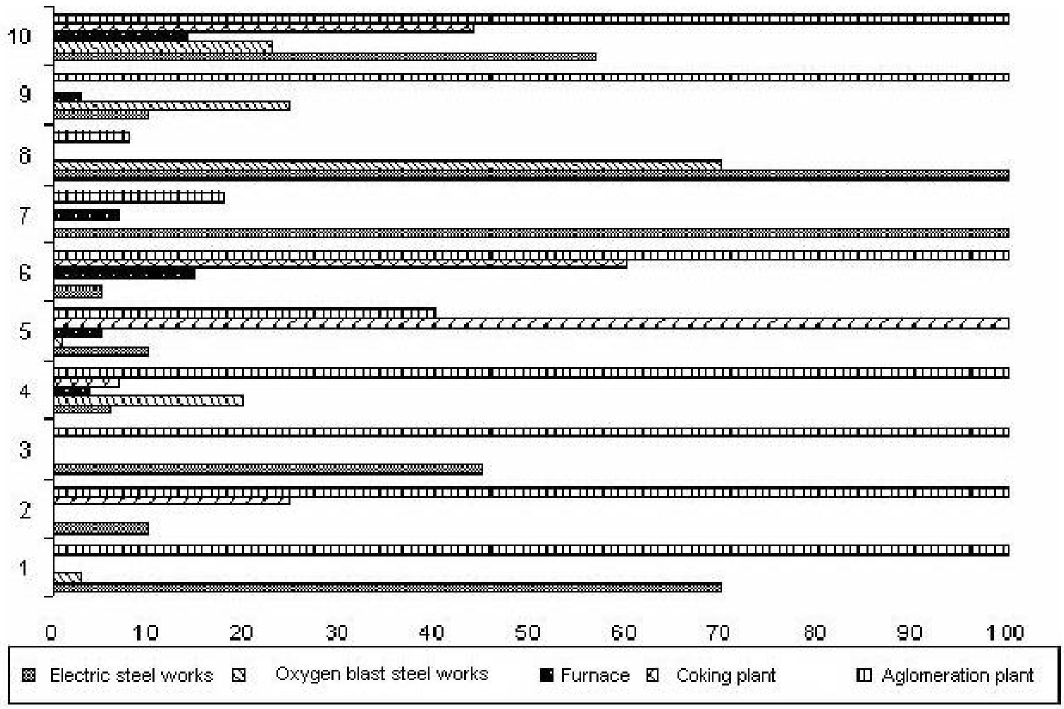

Figure 1 *Relative emissions in the air originating in the primary siderurgical sectors*

Temporary gas emissions appear during the operations of liquid pig iron transport, preliminary treatment and operations of loading, charging and evacuation of the LD converter. The secondary stirring installation and the continuous casting one are less important sources of noxious emissions in the air.

An inert gas can be used to reduce the iron oxides emissions during the operations of liquid pig iron transport and of loading the converter, and the emissions generated during loading can be reduced by optimizing the loading technologies as well as the characteristics of scrap iron (quality, distribution in furnace).

In the case of steel works, there are emissions resulted from secondary gas burning, temporary emissions from the steel works, flashing emissions and the cleaning of the secondary extraction gas.

The secondary emissions during charging can be controlled by providing a tight adjusting between the converter opening and the seal boot of the primary residual gas system, but this can often be prevented by the drops of slag and metal produced during the charging operation.

The secondary gas from the LD converter can be collected and recycled as fuel, although a part of it has to be burnt every time at the beginning and in the end of each charge when the CO concentration is low. Thus, the efficiency of the gas cleaning installation as well as of the gas collecting will have an important effect on the total quantity of the emissions in the air. Technologies apply computerised control systems in order to increase the efficiency of gas collecting.

The converter gas used as fuel has a caloric power of about 9 MJ/m^3, thus saving 0,7 GJ/t of raw steel. In Germany, for instance, the recycling of the converter gas saves the equivalent of 300 Nm^3 of natural gas.

The system works by carrying the hot gas through a recuperator where the heat is used to generate steam (fig.2). Then, the gas goes through a purifying system or through a wet cleaning system, and, when a certain value of the CO concentration is reached, the gas is collected, cooled and stored. The electric filter purifying system has lower power consumption as compared to the corresponding water systems and it is installed in the place where the gas is collected from the converter.

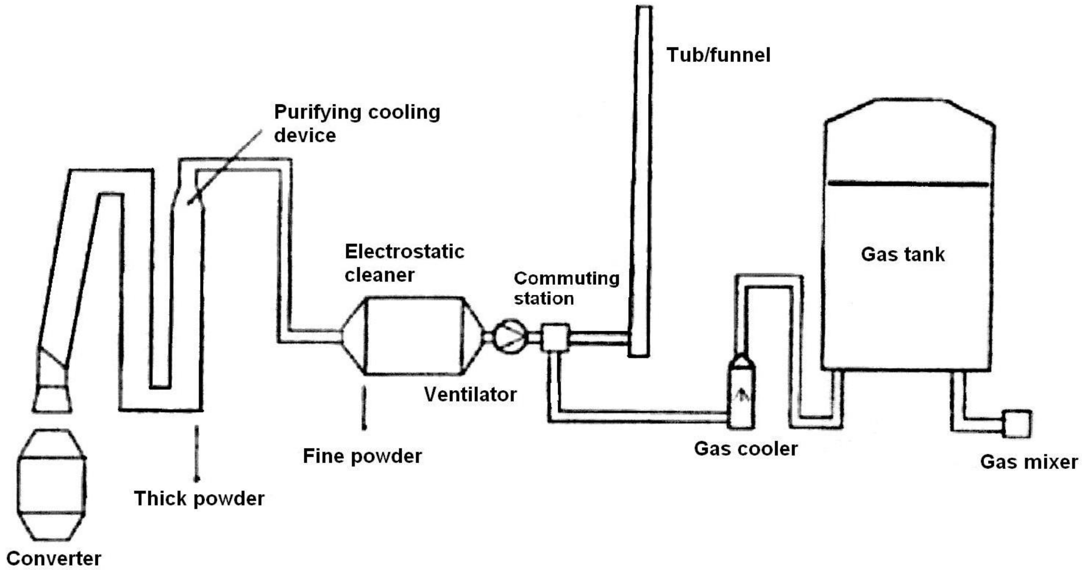

Figure 2 *The purifying and recycling system for LD converter gases*

In electric steel works, a primary extraction system can be used in order to directly collect the emissions generated in the furnace during the melting process and a secondary system can be used to collect the temporary emissions in the steel works during loading, melting and evacuation (fig.3). The primary gas is mainly filtered in order to remove the particles before their being released in the atmosphere, but this system may not be equally efficient in lowering the level of the volatile compounds, of the smoke resulted and of the traces of organic compounds, of volatile metals (e.g. mercury) etc. The level of these compounds can be controlled to a certain extent by sorting and preparing the scrap iron. Another problem in the case of electric furnaces is represented by the dioxin – type toxic gas emissions, for which a series of researches have been made in order to diminish or completely eliminate them.

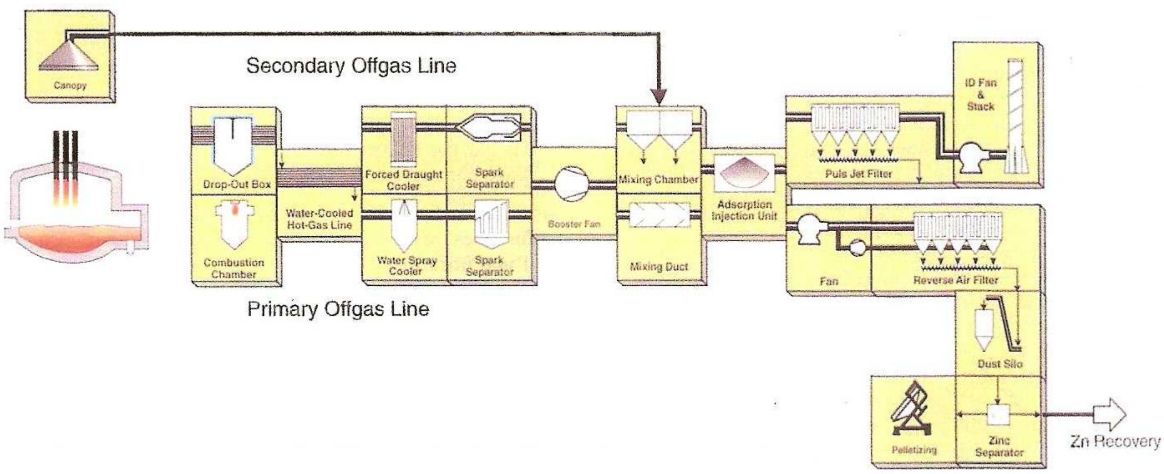

Figure 3 *The situation of the powders collected from the primary and secondary gases evacuated from the electric arc furnaces (data processed from 67 installations)*

3. Modern technologies used to reduce the dioxins emissions in the electric arc furnaces

Among the polluting substances emitted during the metallurgical processes, dioxins are the most toxic.

The problem of dioxins emissions is more acutely raised in the case of electric arc elaboration furnaces, where important quantities of scrap iron (along with the organic and chloride constituents which they inevitably contain) are melted in order to obtain steel.

Dioxins define a group of compounds which consists of about 75 polychlorodibenzodioxins (PCDD) and 135 polychlorodibenzofurans (PCDF).

At high temperatures, dioxins and furans decompose.

In the gas cooling phase, they are remade by the chemical reactions between the organic compounds and the chlorides present in the gas and powder emissions, at temperatures of 200 – 600°C. This "novo" synthesis reaches the maximum intensity between 250 and 400°C. In fig.4, it is schematically presented the variation of the reaction speed in the process of dioxins forming and decomposing, function of temperature raise.

Dioxins remaking depends on the gases kinetics, especially during the above mentioned temperature interval. Thus, in order to reduce these emissions, it is necessary a rapid cooling of the gases resulted in the process, at temperatures bellow 200°C to prevent dioxins remaking.

The strategy for reducing the concentration of dioxins in the electric furnaces emissions is focused on three aspects:

- thermic decomposing as advanced as possible of the dioxins contained in emissions by an extensive exposure of these compounds at temperatures over 850°C;
- prevention of their remaking (by "novo synthesis") during the gas cooling phase by accelerating the process within the temperature domain 600 - 200°C:
- separating the residual dioxins from the emission flow, by injecting an absorbent substance, followed by a filtering operation.

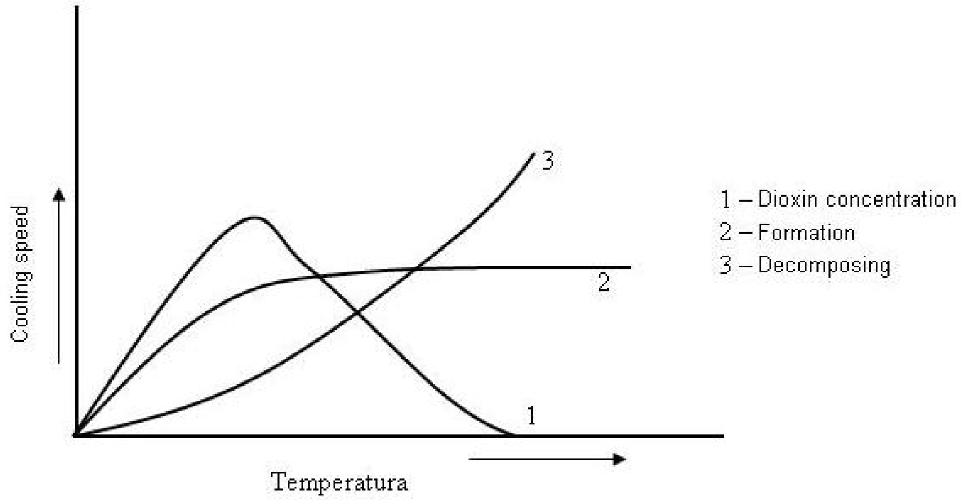

Figure 4 *Dioxins forming function of temperature*

To reduce the dioxin emissions in atmosphere, a modular system for treating emissions was developed, which takes into account the specific conditions of exploitation and the type of electric furnace (classical or tub furnaces).

Each part of the system (equipment) corresponding to a technological treatment stage was optimised in industrial conditions (fig.5).

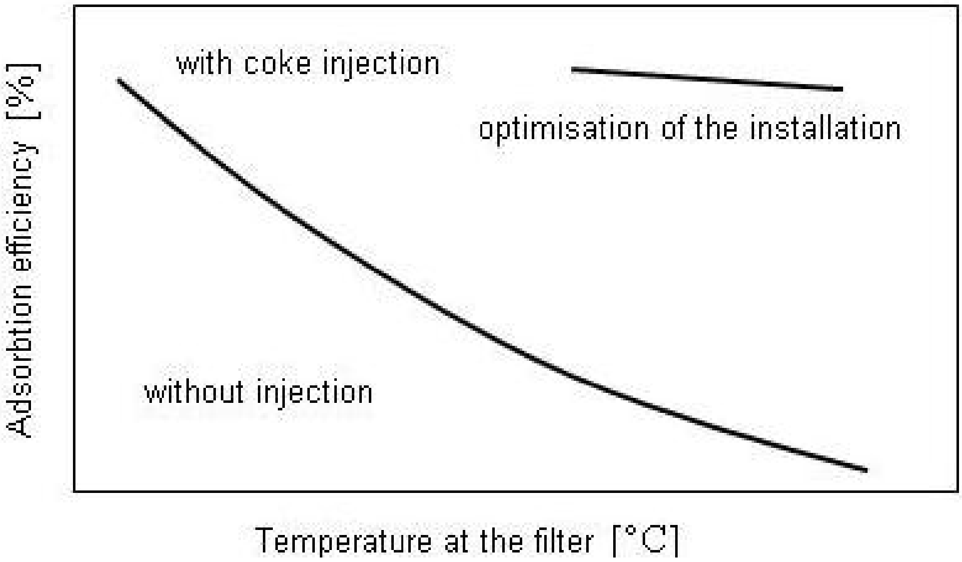

Figure 5 *The efficiency of absorption depending on the filter temperature and the injecting of the absorbent substance*

In the case of classical electric furnaces, a separator was installed, which captures the dust particles and the drops of liquid slag. The hot blast (which includes gases and solid particles) can reach 1000 °C and contains an important quantity of gaseous CO which burns in contact with the injected air.

Simultaneously, the volatile organic compounds contained in the gaseous mixture, together with the dioxins resulted from the organic substances present in the scrap iron and the recycled materials in the charge, are decomposed.

In the case of the "shaft" furnaces, a quantity of air and liquid fuel are injected and burnt in a combustion chamber located at the outlet port of the charge preheating tub in order to achieve a temperature high enough (over 850°C) to assure the decomposing of the organic materials and of the dioxins contained in the mixture of gases and powders evacuated.

The dense particles of powders and the slag drops are evacuated quite efficiently through the filter made by the charge column situated in the preheating room.

Gas cooling

After combustion, hot gases are cooled to approximately 600°C in a pipe cooled by water, and then they are passed either in a mist cooler or in a gas-gas cooler with forced draught to reach a temperature of approximately 200°C. The advantages of mist cooling are: the high cooling speed and, due to a small pressure lowering, the easier circulation through the system.

The forced draught cooling has the advantage that it can function without water (the one which makes the mist), which simplifies the exploitation.

Dioxins absorption

The residual dioxins contained in the gaseous mixture are eliminated by condensation and / or absorption followed by a filtering stage. The efficiency of the process depends on a homogeneous dispersion of the particles having a certain size and shape (with large specific surface) in the emissions mixture to obtain a maximum degree of compression and absorption of dioxins. For the purpose of assuring homogeneity, active carbon (coke) or active carbon mixed with lime were used. The quantity and the quality of the absorption mixture are important factors which assure the security of the installations within the aggregate, with a view to reduce the danger of taking fire and explosion inside the filtering chamber.

The injection system of the absorbent substance is made up of a bin (storage chamber) for the absorbent substance, a ("spider") distribution aggregate and the proper infusion system.

The particles enriched with dioxin are separated from the emission flow in a filtering chamber containing sack filters and unclogging devices with counter-current air. Powders are collected in a bin, and then they are agglomerated to be recycled or evacuated in the end.

Industrial uses

1. System for a tub furnace.

The system of dioxin evacuation has a combustion chamber equipped with CH_4 burners. After leaving this chamber, the exhaust gas and powder mixture goes through a mist cooler. An absorbent infusion device is installed next to the chamber where primary and secondary gases are mixed. The purifying of the dioxin loaded gases is achieved in an air filter.

2. System for classical electric furnaces.

The burnt gases go into a separator where thick particles are eliminated either by the emission flux or by a mist cooler or a forced draught air cooler. Gases go then through a fine filter where the smallest particles are eliminated.

To sum up, we can make the following observations:

- It was noticed that the efficiency of the systems for the removing of dioxins in the electric ovens emissions has been substantially improved by introducing absorbent substances infusion systems;
- The dioxins tendency of concentrating, by absorption and condensation, on the particles of very fine powders (which facilitates their elimination in sack filters) becomes more accentuated as the temperature of the gases at the filter entrance goes lower. This temperature should be under 80°C to assure a removal of the dioxins as advanced as possible.

In the case of the system treating the emissions from an electric furnace, the efficiency of purifying depends on the installation building as well as on the exploitation technology of the equipment.

Conclusions

The dioxins concentration can be reduced at much lower levels than those imposed by the environmental legislation in force, due to the combination between the thermic treatment of the primary emissions (combustion gases), with rapid cooling and gas filtering.

The solutions proposed and experimented correspond to the most advanced techniques concerning environmental protection the introduction of some “clean” technologies in metallurgical engineering.

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