Heavy Metals in Suspended Powders from Steelmaking

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Abstract: - Motivations for controlling heavy metal concentrations in gas streams are diverse. Some of them are dangerous to health or to the environment (e.g. Hg, Cd, As, Pb, Cr), some may cause corrosion (e.g. Zn, Pb), some are harmful in other ways (e.g. Arsenic may pollute catalysts). Within the European community the 13 elements of highest concern are As, Cd, Co, Cr, Cu, Hg, Mn, Ni, Pb, Sn, and Tl, the emissions of which are regulated in waste incinerators. Some of these elements are actually necessary for humans in minute amounts (Co, Cu, Cr, Ni) while others are carcinogenic or toxic, affecting, among others, the central nervous system (Hg, Pb, As), the kidneys or liver (Hg, Pb, Cd, Cu) or skin, bones, or teeth (Ni, Cd, Cu, Cr). Heavy metals occur naturally in the ecosystem with large variations in concentration. In modern times, anthropogenic sources of heavy metals, i.e. pollution, have been introduced to the ecosystem.

Key-Words: - heavy metals, emissions, toxic, human health, anthropogenic sources, pollution of ecosystem

1 Introduction
A heavy metal is a member of an ill-defined subset of elements that exhibit metallic properties, which would mainly include the transition metals, some metalloids, lanthanides, and actinides. Many different definitions have been proposed—some based on density, some on atomic number or atomic weight, and some on chemical properties or toxicity. The term heavy metal has been called "meaningless and misleading" in an IUPAC technical report due to the contradictory definitions and its lack of a "coherent scientific basis". There is an alternative term toxic metal, for which no consensus of exact definition exists either. As discussed below, depending on context, heavy metal can include elements lighter than carbon and can exclude some of the heaviest metals. Waste-derived fuels are especially prone to contain heavy metals so they should be a central concern in a consideration of their use.

2 Problem Formulation
Further processing of steel can include continuous casting, EAFs produce metal dusts, slag, and gaseous emissions. The continuous casting process bypasses several steps of the conventional ingot teeming process by casting steel directly into semifinished shapes. The casting, rolling, and steel finishing processes are also used in iron and steel manufacturing. Hot steel is transformed in size and shape through a series of hot rolling and forming steps to manufacture semifinished and finished steel products. The hot rolling process consists of slabheating (as well as billet and bloom), rolling, and forming operations. Several types of hot forming mills (primary, section, flat, pipe and tube, wire, rebar, and profile) manufacture a variety of steel products. For the manufacture of a very thin strip or a strip with a high-quality finish, cold rolling must follow the hot rolling operations. Lubricants emulsified in water are usually used to achieve high surface quality and to prevent overheating of the product. EAFs produce metal dusts, slag, and gaseous emissions. The primary hazardous components of EAF dust are zinc, lead, and cadmium; nickel and chromium are present when stainless steels are manufactured. The composition of EAF dust can vary greatly, depending on scrap composition and furnace additives. EAF dust usually has a zinc content of more than 15%, with a range of 5–35%. Other metals present in EAF dust...
include lead (2–7%), cadmium (generally 0.1–0.2% but can be up to 2.5% where stainless steel cases of nickel-cadmium batteries are melted), chromium (up to 15%), and nickel (up to 4%). Generally, an EAF produces 10 kilograms of dust per metric ton (kg/t) of steel, with a range of 5–30 kg/t, depending on factors such as furnace characteristics and scrap quality.

Major pollutants present in the air emissions include particulates (1,000 milligrams per normal cubic meter, mg/Nm3), nitrogen oxides from cutting, scarfing, and pickling operations, and acid fumes (3,000 mg/Nm3) from pickling operations. Both nitrogen oxides and acid fumes vary with steel quality.

Air emissions of particulate matter (PM) should be less than 20 mg/Nm3 where toxic metals are present and less than 50 mg/Nm3 in other cases. This would correspond to total dust emissions of less than 1 kg/t of steel. Sulfur oxides should be less than 2,000 mg/Nm3 and nitrogen oxides, less than 750 mg/Nm3. The daily measurements of suspended powders have been made for ten days in five areas of our town.

The values obtained are listed in Table 2.1. These points have been chosen so as to establish the air pollution of this town by the integrated iron and steel work.

The determinations have been made for the heavy metals Cd, Cr 6+, and Pb. The principle of determination methods consist in aspiration an air volume on a diaphragm filter of acetate or nitrate of pulp with the pores dimension of 0.8 – 0.85 µm, the mineralization of these filters in acids mixtures and their dozing by Atomic Absorption Spectrometry. The sensitivity being of 0.05 µg Cd/m3, 0.015 µg Cr/m3, and 0.02 µg Pb/m3 analysed solution for Cd, Cr 6+, and Pb respectively. Sampling has been made by means of Desaga 450.

To estimate the weighting flow capacities of heavy metals emitted in the atmosphere from the melting furnace the contents of these pollutants measured in the powders emitted from the EAF are considered, according to Table 2.1:

<table>
<thead>
<tr>
<th>Emission type</th>
<th>Operation /Place</th>
<th>Scrap</th>
<th>Iron sponge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary</td>
<td>Melting – refining</td>
<td>14</td>
<td>93</td>
</tr>
<tr>
<td>Secondary</td>
<td>Charging</td>
<td>0.4</td>
<td>2.75</td>
</tr>
<tr>
<td></td>
<td>Off-gases</td>
<td>0.5</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>Space from around of furnace</td>
<td>0.1</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td>15</td>
<td>100</td>
</tr>
</tbody>
</table>

The filters system with selenium allows the concentration reducing of mercury below 0.01 mg/Nm3.

Using the results analysed of heavy metals from particles emitted from the electric arc furnaces from steel works the concentrations in emissions and weighting flow capacities of these pollutants have been made.

Table 2.2 Dust emissions from electric arc furnace

The powders resulted during the technological operations of base material loading and steel melting, refining, alloying and evacuation which contain heavy metals (Cr, Ni, Zn, Pb, etc) and can reach values of 15 kg/t steel. The electric arc furnace (EAF) is an important polluting emissions generator, having a strong impact over the environment. From the total polluting emissions, over 90% are generated during the technological operations of melting and refining. These emissions have a high content of iron, manganese,
aluminum and silicium oxides, as well as heavy metals oxides (Ni, Cr, Cd, Pb, Cu). The chemical composition of these emissions is extremely variable and directly dependent on the following parameters:

• the composition of the base materials that make up the loading;
• the melting managing way;
• the refining process that is used (with gaseous oxygen or ore);
• the period the melting and refining last; the grade of the elaborated steel.

3 Problem Solution
A better understanding of the interactions between EAF process and environmental operations should be developed. Future EAF operations will be based on a more holistic approach and it will be necessary to integrate furnace process control with environmental control. The successful EAF operations of the future will be based on real-time measurements of off-gas chemistry to control both the EAF steelmaking process and the EAF fume control system. Research into major process changes of steelmaking are needed. The feasibility of hydrogen-based steelmaking, which generates H2O rather than CO and CO2, may be researched. The potential for sealing the furnace will likely be investigated and developed further. It is already becoming apparent that future furnace designs will use multiple injection points for both gases and solids. This is beneficial for process operations and will allow for greater control of furnace operations.

Offgas system research and a more complete understanding of the combustion chemistry process may help decrease the environmental effects of steelmaking. Furnace offgas systems are typically designed for peak volumes and heat content, which only occur for a small portion of the tap-to-tap cycle. Thus, the offgas system fluctuates between "peaks and valleys" depending on the phase of the cycle. Oxygen injection frequently results in peak conditions due to the high levels of CO generated. If O2 injection is spread out over the full cycle time, the offgas system can be smoothed out, allowing for improved post-combustion operations and decreased peak energy loads to the offgas system.

Research is also needed to discover means to minimize the quantity of EAF fume generated by the steelmaking process and to recover the iron, zinc, and other metals contained in the fume. Periodic additions of carbons and fluxes can exacerbate the emission problem. Tap-to-tap times could also be accelerated so that furnace energy losses are decreased and fume emissions are reduced per ton of steel production. The implementation of post-combustion research could also improve EAF performance.

4 Conclusion
Better control of feed material quality is needed because many of the undesirable components contained in EAF dust are contained in the scrap feed to the furnace. Though scrap selection is primarily an economic consideration, treatment of scrap to eliminate the transfer of undesirable materials into the EAF will likely become necessary in the future. The use of lower grade fluxes and additives containing sulfur is also a concern if the sulfur is not tied up in the slag and instead reports to the offgas stream.

Dust emission control technologies include cyclones, baghouses, and electrostatic precipitators (ESPs). Scrubbers are used to control acid mists. Fugitive emissions from charging and tapping of EAFs should be controlled by locating the EAF in an enclosed building or using hoods and by evacuating the dust to dust arrestment equipment to achieve an emissions level of less than 0.25 kg/t.

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