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ASSESSMENT OF AIR ENVIRONMENTAL FACTOR POLLUTION TO THE STEELMAKING

BY

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Abstract. The steelmaking process in the electric arc furnace causes environmental pollution in all its components: water, air and soil. The electric arc furnace steelmaking is considered to be an industrial process with high degree of pollution because the following pollutants are transferred in the air environment factor: carbon oxide, sulphur oxide, nitrogen oxide, volatile organic compounds, particulate matter, dioxins and furans. The purpose of the paper constitutes the assessment of air environmental factor pollution to the steelmaking in the electric arc furnace. Are presented the results regarding the gaseous emission concentration emitted at the carbon steelmaking from an electric arc furnace. The results were interpreted and compared with concentrations of gaseous emissions existing in the environmental protection standards. According the data obtained, steelmaking process has a negative impact on the air environment factor, so it is necessary to find solutions to decrease the pollutant concentrations.

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Key words: electric arc furnace; pollution; steelmaking; gaseous emission; negative impact.

1. Introduction

The increase of the amount of steel produced worldwide causes a proportional increase in the quantities of pollutants and solid waste (slag, dust) which cover large storage areas and pollute the environment in all its components: water, air and soil.

The results of research presented by Norgate *et al*. (2007) and Sutherland & Haapala (2007) show that the specific elaboration processes of ferrous alloys have a negative impact on air due to emissions of greenhouse gases, acid rain, emissions of dioxins and furans, dusts which contain heavy metals, emissions of volatile organic compounds, etc.

The steelmaking in the electric arc furnace belongs to the category of the industrial processes with high degree of pollution because there are transferred in the air environment factors, the following pollutant substances: carbon oxides, sulphur oxides, nitrogen oxides, volatile organic compounds (VOC), particulate matter, dioxins and furans. The pollution of air environmental factor during steelmaking in electric arc furnaces is manifested throughout this process, which includes the following technological phases: furnace charging, charge melting, refining, desulphurization, dephosphorization and alloying (Iluțiu-Varvara, 2006).

The assessment of the air environment factor pollution during steelmaking is difficult to be quantified because it depends on the charge's constituents. The most pollutant technological phases are charge melting and refining (Iluțiu-Varvara, 2006; Varvara, 2006).

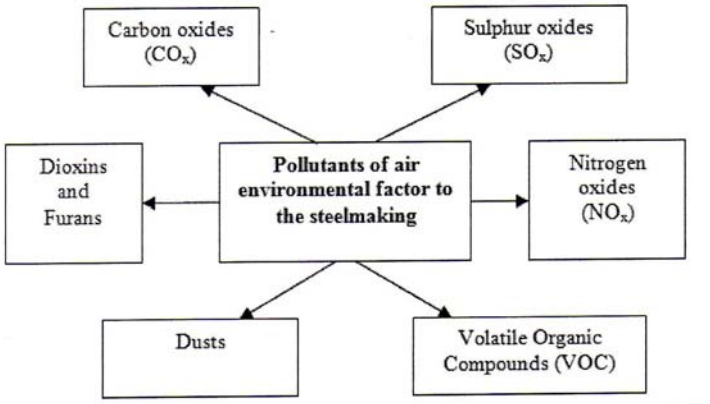

Fig. 1 – The pollutants of air environmental factor to the steelmaking (Varvara, 2006).

The emissions that appear during melting and refining are considered primary emissions. They represent 90% of total emissions. The remaining 10% are emissions generated during charging, so they can come from the charge or can be smoke leakages from the electric arc furnace (Varvara *et al*., 2006).

The process of steelmaking in electric arc furnaces pollutes the air environmental factor with dusts that are released into the atmosphere together with burned gases. The composition and concentration of the burned gases are variable and vary mainly by quality and purity of the furnace charge (Varvara *et al*., 2005).

Fig. 1 presents the categories of air environmental factor pollutants specific to the steelmaking in electric arc furnaces.

2. Assessment of Air Environmental Factor Pollution to the Steelmaking in the Electric Arc Furnace

To assess the pollution of the air environmental factor during steelmaking in electric arc furnaces, there were determined the concentrations, at emission, of the following pollutants: carbon monoxide, sulphur oxides and nitrogen oxides. The measurement of the pollutant concentrations at emission was achieved with an automatic burned gases analyser. The burned gases were analysed from an electric arc furnace having a capacity of 75 t. The type of steel that has been made is carbon steel.

The concentrations at emissions of gaseous pollutants were measured during the melting phase, every five minutes.

In Fig. 2 there are shown the concentrations at emission of gaseous pollutants generated during steelmaking in the electric arc furnace.

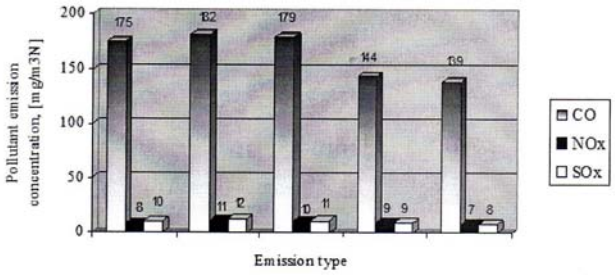

Fig. 2 – The gaseous pollutant concentrations emitted during carbon steelmaking from an electric arc furnace

From Fig. 2 it results that the carbon monoxide is the most encounte-red gas in the composition of burned gases from steelmaking. When the concentration of carbon monoxide increases one can see that the concentrations of sulphur and nitrogen oxides also increase and when the concentration of carbon monoxide decreases one can see that concentrations of sulphur and nitrogen oxides decrease too.

Based to the data presented in Fig. 2, there were determined the average concentrations of carbon monoxide, sulphur oxides and nitrogen oxides. The computation relations are

$$C_{\text{avgCO}} = \frac{C_{1\text{CO}} + C_{2\text{CO}} + C_{3\text{CO}} + C_{4\text{CO}} + C_{5\text{CO}}}{5}, \text{[mg/m}^3\text{N]}, \quad (1)$$

$$C_{\text{avgSO}_X} = \frac{C_{1\text{SO}_X} + C_{2\text{SO}_X} + C_{3\text{SO}_X} + C_{4\text{SO}_X} + C_{5\text{SO}_X}}{5}, \text{[mg/m}^3\text{N]}, \quad (2)$$

$$C_{\text{avgNO}_X} = \frac{C_{1\text{NO}_X} + C_{2\text{NO}_X} + C_{3\text{NO}_X} + C_{4\text{NO}_X} + C_{5\text{NO}_X}}{5}, \text{[mg/m}^3\text{N]}, \quad (3)$$

where: C_{avgCO}, C_{avgSO_X} and C_{avgNO_X} represents, the average concentrations of carbon monoxide, sulphur oxides and nitrogen oxides; $C_{1\text{CO}}, C_{2\text{CO}}, \ldots, C_{5\text{CO}}$ – the concentrations of, respectively, carbon monoxide for the five measurements; $C_{1\text{SO}_X}$, $C_{2\text{SO}_X}, \ldots, C_{5\text{SO}_X}$ – the concentrations of sulphur oxides for the five measurements; $C_{1\text{NO}_X}, C_{2\text{NO}_X}, \ldots, C_{5\text{NO}_X}$ – the concentrations of nitrogen oxides for the five measurements.

In Fig. 3 there are shown the average concentrations of gaseous pollutants from steelmaking, calculated with the relations (1),...,(3).

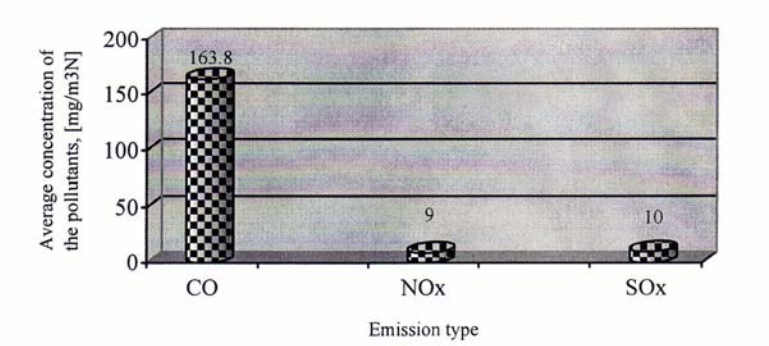

Fig. 3 – Average concentration of the pollutants from the steelmaking in the electric arc furnace.

In Table 1 there are presented the average and maximum allowed concentrations of pollutants in the work place atmosphere, and allowed values for these pollutants at emission.

The concentrations of gaseous pollutants recorded during steelmaking in the electric arc furnace were compared with the allowed pollutants concentrations at emission.

Table 1
The Allowed Concentrations of Pollutants in the Work Place Atmosphere, and Allowed Values for these Pollutants at Emission

Pollutant	Allowed average concentration mg/m^{3}N (Voicu, 2002)	Allowed maximum concentration mg/m^{3}N (Voicu, 2002)	Allowed values at emission (MAPPM,…, 1993)	
			Alert threshold mg/m^{3}N	Intervention threshold mg/m^{3}N
Carbon monoxide	20	30	70	100
Sulphur oxides	5	10	24.5	35
Nitrogen oxides	5	8	245	350

From the analysis of the obtained data it results that

a) the maximum concentration of carbon monoxide is 182 mg/m^{3}N, and the minimum concentration is 139 mg/m^{3}N;

b) the maximum concentration of sulphur oxides (sulphur dioxide) is 12 mg/m^{3}N, and the minimum concentration is 8 mg/m^{3}N;

c) the maximum concentration of nitrogen oxides (nitrogen dioxide) is 11 mg/m^{3}N, and the minimum concentration is 7 mg/m^{3}N;

d) all recorded concentrations of carbon monoxide exceed permissible concentrations levels;

e) the average carbon monoxide concentrations exceed by 2.34 times the alert threshold;

f) the average carbon monoxide concentrations exceed by 1.63 times the threshold for intervention;

g) all recorded concentrations of sulphur oxides are within the allowed values at emission;

h) all recorded concentrations of nitrogen oxides are within the allowed values at emission;

i) the average concentration of sulphur oxides and nitrogen oxides are within the allowed values at emission.

3. Conclusions

1. The pollution of the air environmental factor during steelmaking in the electric arc furnaces is considerable in terms of greenhouse gas emissions.

2. The average concentration of carbon monoxide exceeds the alert threshold by 2.34 times and by 1.63 times the intervention threshold.

3. The average concentrations of sulphur oxides and nitrogen oxides are within the allowed limits at emission.

4. The composition and concentration of burned gases from steelmaking in electric arc furnaces is highly variable and depends mainly on the purity degree of the charge used.

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EVALUAREA POLUĂRII FACTORULUI DE MEDIU AER LA ELABORAREA OȚELULUI

(Rezumat)

Procesul de elaborare a oțelului în cuptorul electric cu arc determină poluarea mediului înconjurător în toate componentele sale: apă, aer şi sol. Elaborarea oțelului în cuptorul electric cu arc este considerată a fi un proces industrial cu grad ridicat de poluare, deoarece în factorul de mediu aer sunt transferați următorii poluanți: oxizi de carbon, oxizi de sulf, oxizi de azot, compuşi organici volatili, praf, dioxine şi furani. Scopul lucrării îl constituie evaluarea poluării factorului de mediu aer la elaborarea oțelului în cuptorul electric cu arc. Sunt prezentate rezultate privind concentrația emisiilor gazoase la elaborarea oțelului în cuptorul electric cu arc. Rezultatele obținute au fost interpretate şi comparate cu concentrațiile emisiilor gazoase existente in standardele de protecție a mediului. Potrivit datelor obținute, procesul de elaborare a oțelului are impact negativ asupra factorului de mediu aer, motiv pentru care este necesară găsirea unor soluții de reducere a concentrației poluanților.