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ASSESSMENT OF AIR POLLUTION WITH SULPHUR DIOXIDE FROM ELECTRIC ARC FURNACES

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ABSTRACT. The purpose of the paper constitutes the assessment of air pollution with sulphur dioxide (SO_2) from the electric arc furnaces. Experimental procedure for determining SO_2 emission levels during the steelmaking and the sulphur dioxide concentrations variation diagrams with the melting temperature of the three types of charges are presented. Sulphur dioxide has a negative impact on the quality of the air, being responsible for generating acid rain. The negative impact of sulphur dioxide manifests itself on the steel works and on the population.

Keywords: *air pollution, sulphur dioxide, electric arc furnace.*

INTRODUCTION

The steelmaking in the electric arc furnace belongs to the category of industrial processes with high degree of pollution because the following pollutants are transferred in the air: carbon oxides, sulphur oxides, nitrogen oxides, volatile organic compounds (VOC), particulate matter, dioxins and furans [1].

Sulphur dioxide (SO_2) forms sulphate aerosols that are thought to have a significant effect on global and regional climate. Sulphate aerosols reflect sunlight into space and also act as condensation nuclei, which tend to make the clouds more reflective and change their lifetimes [2].

Sulphur emissions have grown rapidly and extensive researches have documented a variety of effects on the environment [3]. Sulphur dioxide is the primary cause of acid precipitation, which adversely affects natural systems, agriculture and building materials. The sulphate aerosol particles formed as a consequence of these emissions impair visibility and affect human health.

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Sulphur dioxide, dissolves in the water vapors from the air to form acids and interacts with other gases and particles in the air to form particles known as sulphates and other products that can be harmful to people and their environment [4].

In Table 1, there are presented the health effects of respiratory exposure to sulphur dioxide.

Table 1. Health effects of respiratory exposure to sulphur dioxide [5, 6, 7]

Exposure limits [ppm]	Health Effects
1-5	Threshold for respiratory response in healthy individuals upon exercise or deep breathing
3-5	Gas is easily noticeable. Fall in lung function at rest and increased airway resistance
5	Increased airway resistance in healthy individuals
6	Immediate irritation of eyes, nose and throat
10	Worsening irritation of eyes, nose and throat
10-15	Threshold of toxicity for prolonged exposure
>20	Paralysis or death occurs after extended exposure
150	Maximum concentration that can be withstood for a few minutes by healthy individuals

Sulphur dioxide has a negative impact on the human health. Sulphur dioxide penetrates the human organism through the respiratory system. At high concentrations its absorption reaches up to 90% in the upper respiratory tract and less in the lower parts of the respiratory system. During short-term exposure to sulphur dioxide the respiratory system is mainly affected. Population groups sensitive to sulphur dioxide exposure are children, elderly, asthmatic patients, people suffering from cardiovascular diseases or chronic lung diseases. Sulphur dioxide health effects are expressed in respiratory disorders, lung diseases, lung immune protection disorder, aggravation of existing lung and cardiovascular diseases. The asthmatic patients are ten times more sensitive and sulphur dioxide than healthy people. Children, suffering from asthma are particularly sensitive, and sulphur dioxide exposure may lead to inflammatory lung diseases [1, 6, 8, 9].

The European Union (EU) defines the obligations to be met by industrial activities with a major pollution potential. The objective is to avoid or minimize polluting emissions in the atmosphere, water and soil, as well as waste from industrial and agricultural installations, with the aim of achieving a high level of environmental and health protection [10, 11, 12, 13].

The sources with sulphur dioxide generating potential in the electric arc steelmaking are [9]: the metallic charge; additions of auxiliary materials; first fusion pig iron (0.05 – 0.07% S); electric arc furnace atmosphere, when using fuels containing sulphur.

RESULTS AND DISCUSSION

The composition of the charge I is presented in Table 2.

Table 2. The composition of the charge I

Charge	Composition [%]	Weight [g]
Painted plate	50	5
Zincked plate	20	2
First fusion pig iron	27	2.7
Plastics	3	0.3
Total	100	10

In Fig. 1 sulphur dioxide concentration variation and maximum concentration variation of sulphur dioxide for charge I is represented. The graph shows that the sulphur dioxide concentration increased with the increasing of temperature in the interval 350-450^oC, so that at the temperature of 450^oC reaches the maximum value of 95 [ppm], after which the SO_2 concentration decreases with the increasing of the temperature.

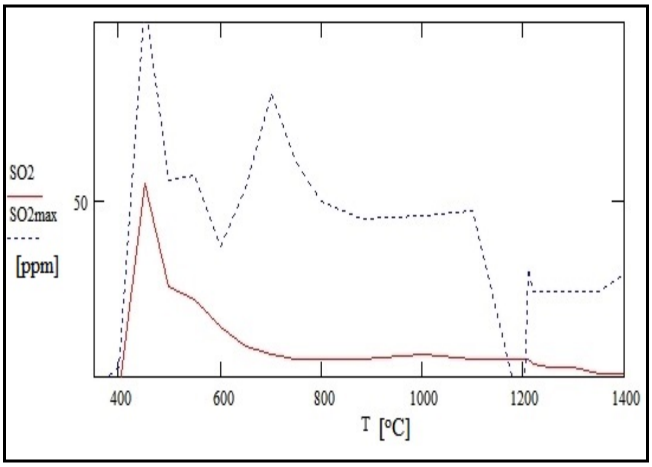

Figure 1. Variation with temperature of sulphur dioxide concentration and maximum concentration variation of sulphur dioxide for charge I

The composition of the charge II is presented in table 3.

Table 3. The composition of the charge II

Charge	Composition [%]	Weight [g]
Painted plate	40	4
Zincked plate	40	4
First fusion pig iron	15	1.5
Plastic and vaseline	5	0.5
Total	100	10

In Fig. 2 sulphur dioxide concentration variation and maximum concentration variation of sulphur dioxide for charge II is represented. The graph shows that the sulphur dioxide concentration decreases with the increasing of temperature in the 520–750°C, 800–860°C and 900-1070°C intervals, and in the intervals 750-800°C and 860 - 900°C sulphur dioxide concentration increases with the increasing of the temperature.

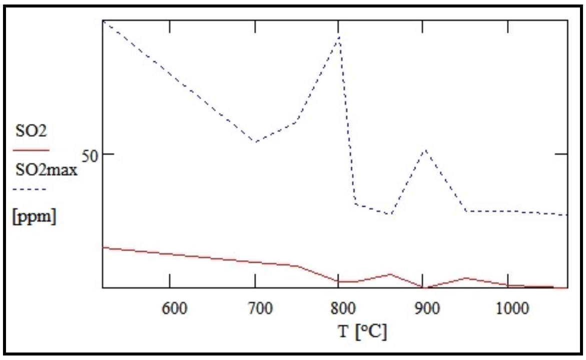

Figure 2. Variation with temperature of sulphur dioxide concentration and maximum concentration variation of sulphur dioxide for charge II

The composition of the charge III is presented in table 4.

Table 4. The composition of the charge III

Load	Composition [%]	Weight [g]
Painted plate	15	1.5
Zincked plate	45	4.5
First fusion pig iron	33	3.3
Plastic and vaseline	7	0.7
Total	100	10

In Fig. 3 sulphur dioxide concentration variation and maximum concentration variation of sulphur dioxide for charge III is represented. The graph shows that in the 680-780°C, 800-850°C and 900-950°C intervals, the maximum sulphur dioxide concentration increases as long as the temperature increases, and in the 780-800°C, 850-900°C and 950-1100°C intervals, decreases as the temperature increases.

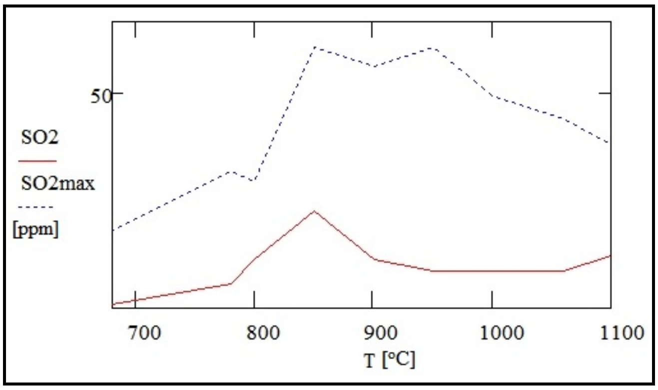

Figure 3. Variation with temperature of sulphur dioxide concentration and maximum concentration variation of sulphur dioxide for charge III

Based on the sulphur dioxide concentrations recorded by the burned gases computer analyzer – MAXILYZER, there were computer the average sulphur dioxide concentrations for the three types of charges analyzed were calculated. Average values are 17.45, 14.90 and 15.00 ppm for the three charges, respectively.

From the analysis of the sulphur dioxide concentrations recorded for the three types of charges, we concluded that the intervention threshold value for SO_2 (13.36 ppm according to the reference [14]) was exceeded by 1.3 times for the first charge, by 1.11 times for the second charge and by 1.12 times for the third charge.

CONCLUSIONS

After analyzing the SO_2 and SO_{2max} concentrations variation graphs for the three charges, it results that: in all the three charges it the presence of sulphur dioxide was detected the presence; the greatest concentration was detected for the charge I (95 ppm); the recorded SO_2 concentrations decreased with the increasing of the temperature; the average concentrations of sulphur dioxide exceed the intervention threshold.

The emissions level of the sulphur dioxide and maximum sulphur dioxide registered for the three charges are influenced by the sulphur contained in the charge components.

In order to reduce sulphur dioxide emissions it is necessary to select the charge and to preheat the furnace. The charge components selection process refers to the reduction/elimination of the sources having a potential to generate sulphur dioxide. The techniques to reduce the air pollution with sulphur dioxide from electric arc furnaces include the followings: the selection of raw materials (first fusion pig iron; scrap with low sulfur content); the usage of fuel with low sulfur content, such as natural gas; flue gas desulphurization (absorption, adsorption, catalytic oxidation and catalytic reduction).

The original aspects of the article are: conception of three types of charge for determining the sulphur dioxide concentrations; identification of air pollution sources with sulphur dioxide from electric arc furnaces; identification of techniques to reduce the sulphur dioxide concentration; assessment of air pollution with sulphur dioxide from electric arc furnaces.

Also for monitoring sulphur dioxide emissions from steelmaking plants it is necessary to achieve a database containing charge compositions, which will make possible the prediction of the emissions concentrations.

EXPERIMENTAL SECTION

In order to determine the sulphur dioxide emissions, which are transferred during steelmaking, three charge types were considered.

In order to realize these determinations, the following equipments were used: an analytical balance; a contact thermometer MICROTEC DIGITEMP 01K; nacelles; a mono-phased electric furnace with chamber type resistance with spirals (model WG/ r01/1522/ 2 VEB) having the following characteristics: P = 2 KV, Umax = 250 V, Imax = 9A, Tmax = 1650°C and transformer of type RFT/SST / 250 V / 20A; a computer for burned gases analysis MAXILYZER.

The nacelle which contains the considered charge was introduced in the furnace with chamber type resistance with spirals, without prior heating, for charges I and III and with preliminary heating at 520°C.

Sulphur dioxide emissions were determined in the 350-1400°C interval (T_1 = 350°C, T_2 = 400°C, T_3 = 450°C, T_4 = 500°C, T_5 = 550°C, T_6 = 600°C, T_7 = 650°C, T_8 = 700°C, T_9 = 750°C, T_{10} = 800°C, T_{11} = 880°C, T_{12} = 1000°C, T_{13} = 1100°C, T_{14} = 1200°C, T_{15} = 1210°C, T_{16} = 1220°C, T_{17} = 1250°C, T_{18} = 1300°C, T_{19} = 1350°C and T_{20} = 1400°C), 520-1070°C (T_1 = 520°C, T_2 = 700°C, T_3 = 750°C, T_4 = 800°C, T_5 = 820°C, T_6 = 860°C, T_7 = 900°C, T_8 = 950°C, T_9 = 1000°C and T_{10} = 1070°C) and 680-1100°C (T_1 = 680°C, T_2 = 780°C, T_3 = 800°C, T_4 = 850°C, T_5 = 900°C, T_6 = 950°C, T_7 = 1000°C, T_8 = 1060°C and T_9 = 1100°C) for charge I, II and III, respectively.

The concentrations of the sulphur dioxide were red every two minutes.

The variation diagrams for the three types of charges were made using MathCAD 7 Professional software.

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