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ISSN 0543-5846
METABK 55(1) 44-46 (2016)
UDC – UDK 669.011.66-9:622.62.66.74:62.004.8=111

EMISSION OF POLLUTANTS FROM THE COMBUSTION OF COMPOSITE FUELS BY METALLURGICAL PROCESSES

Received – Primljeno: 2015-01-25
Accepted – Prihvaćeno: 2015-07-25
Preliminary Note – Prethodno priopćenje

This paper presents the results of the study on emission characteristics of pollutants resulting from *combustion process of* composite alternative fuels for use in the *processes of pyrometallurgy* of *copper* as an alternative fuel to currently used coke breeze. These fuels are mainly based on waste carrier of "C" element, and the *composition* of the *fuel* is modelled in order to obtain the appropriate energy and emission parameters as well as *strength parameters.* These studies confirmed the possibility of using composite fuels as an alternative reducing agent as well as an energy carrier in the processes of pyrometallurgy of copper.

Key words: metallurgical process, alternative fuels, emission, coal, waste materials

INTRODUCTION

Fine tailings produced as a result of hard coal beneficiation process and its preparation, not so long ago regarded as useless materials, are gaining more and more often value as minerals. The most common method of their industrial development is the production of alternative fuels for energy. Increasingly, intense research is being conducted on the possibility of using them as carbonaceous materials in metallurgical processes, e.g. in the iron ore sintering process, in the pyrometallurgical processes for the preparation of copper or in the process of recycling of metal-bearing materials [1 – 4]. The possibility of using these waste carbonaceous materials in metallurgical processes depends on a number of factors, the most important of which include: chemical composition, calorific value (that depending on the chemical composition of the fuel), granulation and shape, strength characteristics as well as emission characteristics [5 – 12].

The results of the study on the emission of pollutants from the combustion of a composite formed fuel for use in pyrometallurgical processes of copper as an alternative fuel for currently used coke breeze are shown below.

MATERIALS

The parameters of fuels used in this study are shown in Table 1.

Table 1 **Characteristics of fuels combust during the test**

fuel no.	graining / mm	composition of dry mass	calorific value / MJ•kg^{-1}
1	pellet ϕ 12 L = 20 ÷ 30	67 % fine coal*) 30 % fine brown coal 3 % binder	26,71
2	pellet ϕ 14 L = 20 ÷ 30	15 % fine coal*) 68 % breeze coke 15 % fine brown coal 2 % binder	28,62
3	pellet ϕ 20 L = 30 ÷ 35	68 % fine coal*) 30 % coke dust 2 % binder	27,95
4	pellet ϕ 20 L = 30 ÷ 35	78 % fine coal*) 20 % fine brown coal 2 % binder	27,90

*) product of flotation

RESEARCH METHODOLOGY

The combustion process was carried out in the boiler equipped with an automatic fuel charge with retort burner and in the boiler with manual fuel charge, respectively. The flue probe was installed in the flue pipe for combustion gas sampling directing to the aspiration system and then into the combustion gas analysers. The water-circulating pump was used to circulate water in the boiler. The heat collection system consisted of a heating coil with a power rating of 25 kW and a heat exchanger that worked as stabilizing system of heat removal from the boiler. The combustion gas analyser consists of two devices operating in parallel: Gasmet ™ DX 4 000 (Gasmet Technologies Inc.) and OXYMAT 61 (Siemens). Gasmet ™ DX 4 000 is a spectroscopic analyzer using Fourier Transform Infrared (FTIR) spectroscopy. Measuring cell works at a temperature of 180 °C, whereby the gas components are measured in the gas phase during the measurement. OXYMAT 61 was used to measure the concentration of oxygen in the combustion gas. The OXYMAT 61 measures oxygen using the paramagnetic alternating pressure method in range 0 to 100 % of O_2. Both these devices were connected to the computer and the results were archived and processed using Calcmet™ Standard (version 11.117) software.

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STUDY RESULTS AND DISCUSSION

In this study the measurements of energy and emission parameters of four types of fuels that differ in both granulation and composition were carried out (Table 1). The study was conducted in two types of boilers, i.e. boiler equipped with an automatic fuel charge and boiler with a manual fuel charge. During the study combustion gas composition measurements were performed, i.e. the concentration of CO, NO, N_2O, NO_2, SO_2, NH_3, HCl, CH_4, C_2H_6, C_2H_4, C_2H_2, CHOH as well as the percentage of O_2, CO_2 and water vapour were determined.

Table 2 summarizes the mean values of concentrations of gaseous components emitted during the combustion processes of composite solid fuels. In contrast, Figures 1 - 4 show the concentrations of gaseous components emitted during the combustion processes of composite solid fuels.

An analysis of the obtained measurement data shows that:

1. The combustion of fuel no. 1 produced the best energy and emission parameters. This fuel was burned in the boiler equipped with an automatic fuel charge at stable operating conditions. The resulting boiler efficiency and average capacity were 62 % and 21,17 kW, respectively.

Table 2 **Statement of researches composite fuels characteristic**

fuel no.		1	2	3	4
boiler		auto	manual	manual	manual
flue gas component	unit	mean concentration			
H_2O (g)	% obj.	2,29	0,47	3,84	0,69
CO_2	% obj.	3,57	4,00	5,57	4,49
O_2	% obj.	15,50	13,04	15,31	16,81
CO	ppm	1 181,0	20 959,3	4 243,55	6 924,67
N_2O	ppm	0,58	1,60	0,95	0,95
NO	ppm	363,00	284,57	365,92	321,89
SO_2	ppm	354,11	305,45	362,88	305,19
NO_2	ppm	0	3,26	0,75	1,82
NH_3	ppm	2,95	3,80	0	1,89
HCl	ppm	10,83	17,32	22,05	14,27
CH_4	ppm	3,83	506,80	167,88	1 031,45
C_2H_6	ppm	2,69	200,33	44,55	109,66
C_2H_4	ppm	6,59	55,85	36,45	102,54
CHOH	ppm	1,33	6,11	6,67	9,18

2. The study carried out for fuel no. 2 dedicated to boilers equipped with a manual fuel charge, with a dominant share of coke breeze. This study showed very negative emission characteristics of the fuel. Graph analysis revealed that in the initial period of fuel combustion approx. to 100 min. the gasification process occurs that produces water gas. This is evidenced by the high concentrations of CH_4, C_2H_6, C_2H_4 and CO and the low level of moisture content in combustion gas of 0,47 % vol and 071 % vol, respectively. The resulting efficiency of the boiler is at a level of about 25,2 % and the resulting average boiler capacity is 10,12 kW.

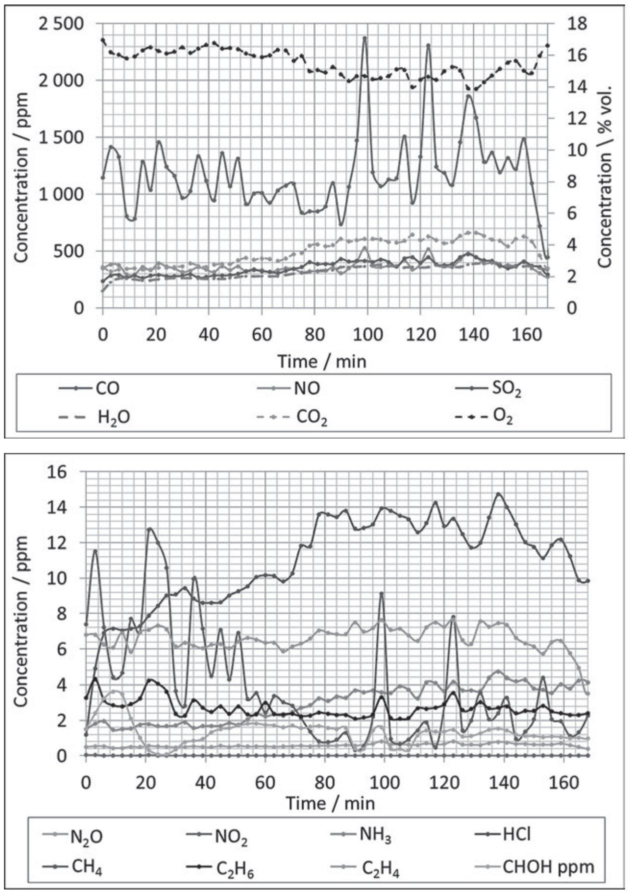

Figure 1 The concentrations of the gaseous pollutants emitted during combustion of the fuel 1

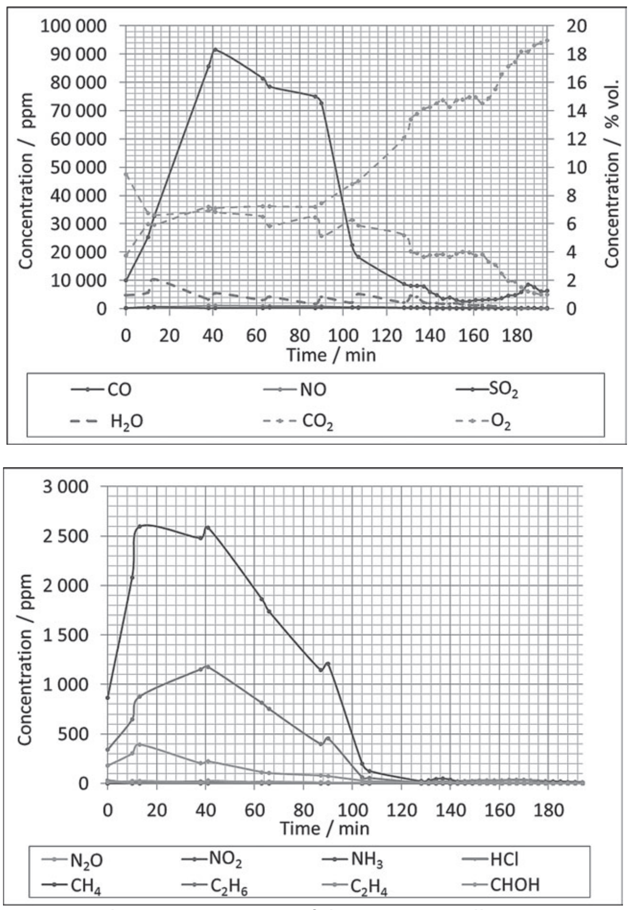

Figure 2 The concentrations of the gaseous pollutants emitted during combustion of the fuel 2

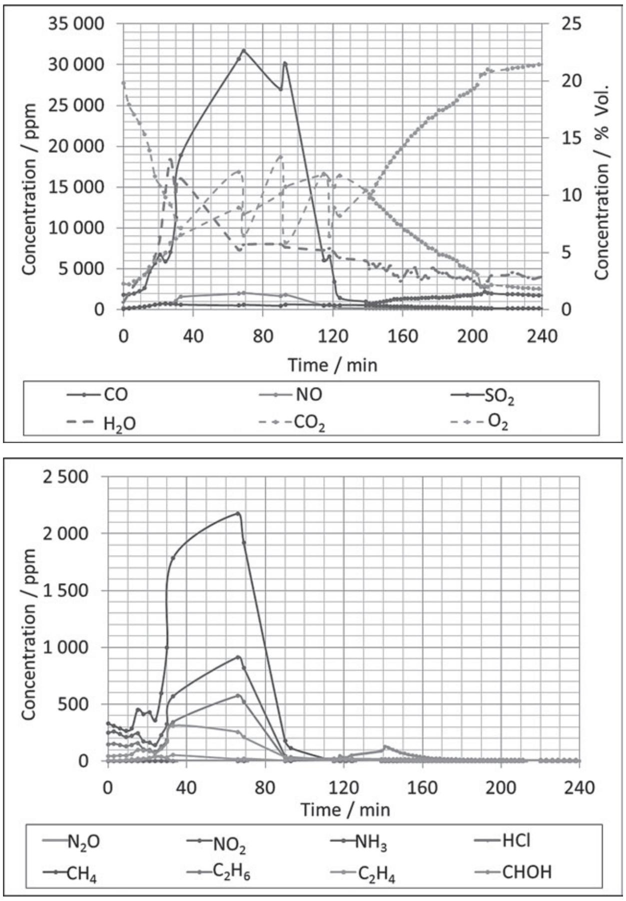

Figure 3 The concentrations of the gaseous pollutants emitted during combustion of the fuel 3

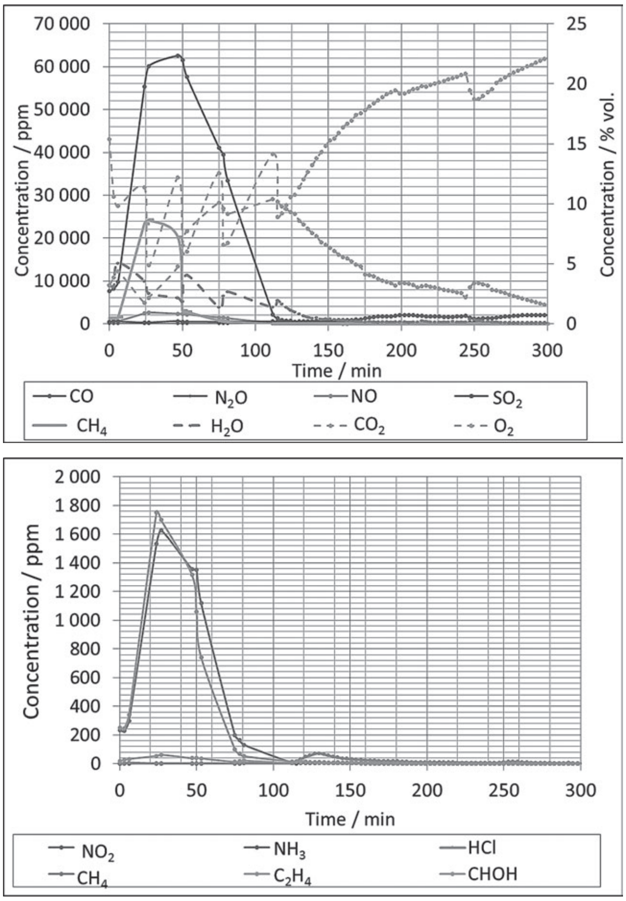

Figure 4 The concentrations of the gaseous pollutants emitted during combustion of the fuel 4

3. In the case of fuel no. 3 having a reduced level of coke breeze to 30 %, the *gasification process also occurs*, however, the most of the gases are combusted as evidenced by reduced concentrations of CO, CH_4, C_2H_6, C_2H_4 in comparison to fuel no. 2. This fuel combusts more efficiently and the boiler provides the average power at 16,76 kW and efficiency of 51 %.
4. Fuel No. 4 examined in the research showed *similar combustion characteristics to* fuel no. 2, except the lower CO concentration level, but still *emission of combustible gases* like CH_4, C_2H_6, C_2H_4 from a boiler was *observed*. The thermal efficiency of the boiler was 53 % while the average power of the boiler was 15,01 kW.

SUMMARY

These energy-emission studies confirmed the possibility of using waste carriers of "C" element as components of composite fuels and their applications as an alternative reducing agent as well as an energy carrier in the processes of pyrometallurgy of copper. With the possibility of influence on the composition of the composite formed *fuel*, it is possible to control its parameters such as the calorific value, volatile matter content, strength etc., and as a consequence its quality remains unchanged. In addition, *it is possible to* dedicate composite formed *fuel* to a particular pyrometallurgical process.

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Note: O. Rachowska-Siwiec is responsible for English language, Katowice, Poland