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THE INFLUENCE OF ORGANIC AND INORGANIC ADDITIVES ON THE SPECIFIC ELECTRICAL RESISTANCE OF COKE

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It is known that blast-furnace coke plays a very important role in iron production. With this in mind, blast-furnace coke is subjected to continuous quality control to ensure its high strength and high resistance to interaction with CO_2. On the other hand, standard test results do not adequately predict the behavior of coke in blast furnaces, simply because they do not accurately reflect actual operating conditions.

There is growing interest in modification of coal when it is at the plastic state in coking, so as to improve coke quality and expand the resource base for coke production in the context of the current deficit of coking coal. One approach is to introduce various modifying additives in the coking batch [1].

Summarizing the long-term practice of many researchers and producers of coking coal charges with different additives, it is possible to propose a conditional classification of these additives into three main groups, depending on their technological origin. (Table 1)

Table 1. Classification of additives in coal charges

Additives in the coal charge		
Inorganic and non-sticky	Organic (caking)	Mesogenic

The group of inorganic additives includes oxides, carbonates, carbides, etc., and descriptive ones include anthracite, semi-coke, coke fines, and dust._Organic additives are mainly solid and liquid wastes of petrochemical (acidic tars, oil sludge, used oils, lubricating and cooling fluids) and coke-chemical industries (acidic tar, carbon blacks).

In this work, the effect of adding both inorganic (boron carbide nanopowders and silicon carbide (carbundum)) and organic (petroleum coke) additives on the quality of the obtained coke was studied, including the specific electrical resistance of the blast furnace coke, which is characterized by the degree of orderliness in its structure [2].

To determine the quality indicators of coals, coal blends and obtained blast-furnace coke, we used the following standard methods: Proximate analysis; Manual sampling; Ultimate analysis; Determination of total sulfur; Calculation of analyses to different bases; Method of determining microscopically the reflectance of vitrinite; Method of determining maceral group composition; Determination of coke reactivity index (CRI) and coke strength after reaction (CSR); Size analysis by sieving; . Method for determination of plastometric indexes.

The essence of the methodology is as follows. A metal chamber with the following dimensions was inserted into an electric furnace preheated to 1100 °C: width – 150 mm, length – 270 mm, height – 300 mm. The chamber was loaded with 4.5–5.0 kg of the tested mixture of coal in a specified grinding class of less than 3 mm with a mass fraction of total moisture of 8±0.5 %; loading density was ~800 kg/m^3. Upon reaching a temperature equal to 950±10 °C in the loading center, the research was stopped. The duration of the experiment was 2 hours 50 minutes – 3 hours. Coke quenching is dry. The coke was weighed and the yield of dry gross coke from dry coal loading was determined.

Coal concentrates (CPP "Pavlogradska", CPP "Dobropilska", grade "G (G1)"; CPP "Dobropilska", grade "G(G2)"; CPP "Svyato-Varvarynska", grade "K") were studied by the methods of proximate (W^r_t, A^d, S^d_t, V^{daf}), plastometric (x, y) and petrographic (R_0, petrographic composition, analyses. The results of the study are shown in Tables 2 and 3.

Table 2. Technological properties

Component	Grade	Proximate analysis, %				Plastometric indexes, mm	
		W^a	A^d	S^d_t	V^{daf}	x	y
CPP "Pavlogradska"	DG	2.1	6.4	1.38	42.3	48	9
CPP "Dobropilska"	G (G1)	1.3	4.6	1.11	39.3	44	16
CPP "Dobropilska"	G G2)	1.1	6.2	1.33	38.7	38	16
CPP "Svyato-Varvarynska"	K	1.1	9.1	0.69	27.3	25	15
Petroleum coke		0.6	0.5	4.08	13.2	Not defined	

Analyzing the given data, it can be concluded that the studied coal is characterized by its inherent values of quality indicators, but it is necessary to note the reduced ash content of the "G (G1)" coal (4.6 %), which can positively affect the ash content of the coke obtained from it.

Table 3. Petrographic characteristics

Componen	Grade	Petrographic composition (without mineral impurities), %					Index of reflection vitrinite, %
		Vt	*Sv*	*I*	*L*	*∑FC*	R_o
CPP "Pavlogradska"	DG	69	0	24	7	24	0.62
CPP "Dobropilska"	G (G1)	63	0	26	11	26	0.78
CPP "Dobropilska"	G (G2)	71	0	23	6	23	0.78
CPP "Svyato-Varvarynska"	K	87	0	12	1	12	1.17
Petroleum coke	Not defined						

Technological indicators of the quality of petroleum coke are given in Table I, and ultimate and granulometric compositions are in Tables 4 and 5.

Table 4. Ultimate composition of petroleum coke

Ultimate analysis (dry, ash-free state), %				
C^{daf}	H^{daf}	N^{daf}	S_t^d	O_d^{daf}
89.87	4.11	1.02	4.08	0.92

Table 5. Granulometric composition of petroleum coke

Granulometric composition (mm), %						Average particle diameter, mm
>13	6–13	3–6	1–3	0.5–1	<0.5	d_s
13.7	18.2	14.0	19.6	11.5	22.9	6.15

Analyzing the results of determining the quality of the obtained coke, it can be stated that the introduction of 5 % of petroleum coke into coal charges leads to increase in gross coke output by 1.2–1.3 %; reduction of coke ash content by 0.2–0.3 %; increasing the total sulfur content of coke by 0.15–0.23 %; deterioration of both mechanical (P25 – by 0.1–0.6 %; I10 – by 0.1–0.2 %) and post-reaction (CSR – by 0.6–1.0 %) strength, reactivity (CRI – by 0.2–0.3 %) of coke, as well as structural strength (SS by 0.3–0.4 %), abrasive hardness (AH by 0.7–1.0 mg) and specific electrical resistance (ρ by 0.002–0.007 Om·cm).

In addition, it should be noted that a sharper deterioration in the quality of blast furnace coke is observed when using a coal charge characterized by a lower coal content of the CPP "Svyato-Varvarynska". This is a consequence of the positive influence of this coal on the quality indicators of blast furnace coke obtained with its participation. On the other hand, taking into account the insignificant deterioration of coke quality indicators, and taking into account certain technical and economic tasks of each individual coke chemical enterprise, the introduction of up to 5% of petroleum coke into coal charges as an additive can be used for the purpose of its utilization and for the purpose of increasing the yield of gross coke.

At the same time, the introduction of a certain amount (0.25 wt. %) of non-caking nano additives B4C and SiC allows to modify the processes that occur when the coal charge is plastic, with a further increase in coke strength. So the *CRI* and *CSR* values of the coke are improved on introducing modifying nanoadditives in the coal batch in quantities no greater than 0.25 wt. %. The influence of nanoadditive B_4C and SiC on the coke properties depends significantly on the rank composition of the batch. The proposed additives are particularly effective in batch with poor coking properties.

The additives may be introduced in the batch by means of a feeder (of screw type, for example) supplying the dosed quantity of additive (0.25 wt. %) to a belt conveyer with the batch. The feeder must precede the final crusher (producing the < 3 mm class). The crusher then acts as a mixer. As we know, uniform mixing of the additive over the whole batch volume is required. Another option is injection by compressed air in the lower part of the silo for one batch component. That entails installing a bunker for the additive in the existing pneumatic system.

References

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