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ИССЛЕДОВАНИЕ ПОВЕДЕНИЯ КАМЕННЫХ УГЛЕЙ ПРИ КОКСОВАНИИ

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INVESTIGATION OF THE BEHAVIOR OF COAL DURING COKING

Introduction

The study of the thermal characteristics of coking of a charge made up of various grades of coking coals is of great theoretical and practical interest. The thermal characteristics of various grades of coking coals will allow, in combination with other factors, to study in detail many aspects of the coking process, classify coals according to their thermal properties, determine to what extent the share of coals of various grades affects the value of the heat of coking of the charge, more accurately assess the performance of coke batteries and establish the necessary changes in the thermal regime with changes in the composition and properties of the charge [1, 2].

The relevance of the work carried out is justified by the need to determine the thermal characteristics of coking coals to ensure the possibility of developing the optimal composition of the charges when obtaining coke products of the required quality.

The topic of the work corresponds to the Priority areas of development of science, technology and engineering of the Russian Federation.

Coking is a complex physico–chemical process of processing coking grades of coal without air access to obtain the final product of coke, as well as by-products. When the coal charge is heated, heat transfer occurs unevenly, since coal is modified during heat treatment, at this time a complex of chemical reactions and thermodynamic processes (melting, evaporation) occurs, accompanied by the release or absorption of heat [3, 4].

It includes the main stages:

• Up to 200 °C – H2O, CO, CO2 is released, drying and decarboxylation are underway;

• 200-350 °C – the beginning of methane release;

• 350-470 °C – coal turns into a plastic state, tar production begins;

• 450-550 ° C – the mass solidifies into a semi-coke, intensive resin release occurs;

• 550-900 °C – release of low molecular weight gases, mainly hydrogen. Coke formation;

The thermal conditions in which coking of coals takes place require a deep understanding and control of the processes of heat and mass transfer inside the coal loading. The selection of coal grades in accordance with similar thermal properties contributes to the choice of the direction of charging, which in turn ensures the rational use of coal concentrates. This approach is particularly valuable when concentrates are represented by coals of several brands or types having similar quality indicators, but with different sintering properties [5].

A number of factors affect the energy efficiency, resource conservation and quality of coke: humidity, ash content, degree of grinding, the presence of mineral impurities and their composition. In this work, the emphasis is on the dependence of temperature and humidity [6].

The purpose of the work is to study the physico-chemical properties of coals and their behavior during coking, depending on temperature and humidity.

For the study, coking coals of the Kuznetsk basin brands were selected, representing the optimal grade composition of the charge for coking: C, CO, J and GJ. These coals are pre-prepared, dried and dispersed on a 3 mm sieve, the quality of the coals is shown in Table 1.

Table 1

Coal quality indicators

Brand of coal	**Technical analysis**		**Plastometry**		**Petrography**	
	A^d	V^d/V^{daf}	X	У	R_0	Vt
	%	%	мм	мм	%	%
C	8,0	24,6/26,7	40	14	1,077	60
CO	8,3	26,0/28,4	44	10	1,056	53
J	8,6	32,5/ 35,5	15	28	0,887	91
GJ	7,2	33,0/35,6	37	21	0,820	89

The change in the moisture content of the charge is one of the main factors that significantly affects the thermal regime of coke ovens, as well as the heat consumption for coking. Moisture changes the thermal properties of the charge. According to the literature data, the thermal conductivity coefficient (λ) at 100 ° C for water is 0.679 W/m·K, for coal grade G – 0.133 W/m·K; specific heat (C_p) at 20 °C for water – 4.18 kJ/ m·K and for coal grade C – 1.34 kJ/ m·K. However, the thermal conductivity coefficient for wet material is significantly higher than for dry and water separately.

Discussion of the results

A study was conducted with absolutely dry coal (humidity is less than 1%) and coal with a humidity of 9%. The results are shown in table 2.

For dry coals, areas where an intensive temperature increase is noted (heating rate of more than 10 ℃/min) have been studied. For C grade coal, this site is in the temperature range of 324.0 – 930.8℃, the maximum heating rate is 69.7℃/min, and the average is 23.8℃/min. For coal grade CO – 344.8 – 939.1℃, the maximum heating rate is 36.0℃/min, the average is 19.5℃/min. For coal grade J – 352.1 – 892.3℃, the maximum heating rate is 36.2℃/min, the average heating rate in this range is 19.7℃/min. For coal grade GJ – 327.5 – 915.3℃, the maximum heating rate is 45.2℃/min, the average is 21.4℃/min.

As a result of the study, the most rapid temperature increase is observed during coking of dry coal of the C brand, the lowest heating rate was revealed for dry coal of the CO brand. The final coking temperatures for these coals should be noted. For C grade coal, the final temperature in the loading center is 1042.2℃, for CO grade coal – 1041.8℃, for J grade coal – 1045.0℃, for GJ grade coal - 1043℃.

Table 2

Thermal characteristics of dry and wet coals

Brand of coal	**DRY COALS**				**COALS WITH A HUMIDITY OF 9%**			
	Intensive heating area, °C	**V_{max},** °C/min	**V_{cp},** °C/min	**T_{fin},** °C	Intensive heating area, °C	**V_{max},** °C/min	**V_{cp},**°C/min	**T_{fin},** °C
C	324,0 – 930,8	69,7	23,8	1042,2	178,2 – 937,1	65,8	24,8	1040,1
CO	344,8 – 939,1	36,0	19,5	1041,8	198,2 – 944,1	54,0	23,0	1032,6
J	352,1 – 892,3	36,2	19,7	1045,0	278,3 – 927,1	52,2	23,5	1042,4
GJ	327,5 – 915,3	45,2	21,4	1043,0	272,2 – 932,8	53,7	19,7	1042,1

As for wet coals, the heating rate in areas with an intense temperature increase is: for C grade coal in the temperature range of 178.2 – 937.1℃, the maximum heating rate is 65.8℃/min, and the average is 24.8℃/min. For coal grade CO – 198.2 – 944.1℃, the maximum heating rate is 54.0℃/min, the average is 23.0℃/min. For coal grade J – 278.3 – 927.1℃, the maximum heating rate is 52.2℃/min, the average heating rate in this range is 23.5℃/min. For coal grade GJ – 272.2 – 932.8℃, the maximum heating rate is 53.7℃, the average is 19.7℃/min.

The temperature in the loading center at the end of the coking process decreased in comparison with dry coals: for C grade coal – 1040.1℃, for CO grade coal – 1032.6℃, for J grade coal – 1042.4℃, for GJ grade coal – 1042.1℃. It should be noted that even at the final temperature of 1032.6℃ at the loading of coal of the CO brand, the coke is fully formed.

As a result of the conducted research, it is worth noting that a change in the humidity of coal directly affects the heating intensity of the loading center and the final coking temperature compared with absolutely dry coal. However, the behavior of the studied brands under thermal heating is ambiguous. It is necessary to conduct additional experiments to study the physico-chemical processes occurring in coal under conditions of temperature change. To clearly separate the entire heating period by stages and compare the data obtained with other studies.

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