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ANALYSIS OF CHARACTERISTICS OF COAL-WATER SLURRIES OBTAINED BY PLASMA AND ELECTRIC DISCHARGE METHODS

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ABSTRACT

The aim of the research is to obtain coal-water slurry, corresponding to modern requirements, with a minimum of energy. The paper presents the characteristics of coal-water slurries prepared by plasma and electric discharge methods. As a raw material used D-grade coal. By electron scanning microscopy was determined the chemical composition of suspensions and removed micrographs of the surface. Micrographs show that the samples processed through both methods have pronounced dispersed structure, compared with the original. Elemental analysis showed a significant reduction in the oxides of sulfur and nitrogen. The results obtained make it possible to draw a conclusion about the availability of receiving coal-water slurries with new plasma and electric-discharge methods.

Keywords: coal water slurry fuel, plasma and electric discharge methods, scanning electron microscopy, elemental analysis.

INTRODUCTION

Energy development, as well as improving energy security of Russia is largely dependent on extensive and effective use of coal as an energy fuel. For this it is necessary, primarily, to improve the properties of the coal consumption as the energy consumption, as well as to master obtaining coal-based fuels with alternative replacement scarce natural resources and the liquid petroleum gas fuel. To solve the above mentioned problems are very promising as performed in Russia and abroad technology of preparation and use of coal slurries which are dispersed composite system consisting of a solid phase in the form of finely divided coal and a liquid medium (water, alcohols, hydrocarbons, refined petroleum products). most studied and promising in energy is coal water slurry fuel (CWSF) in which the main part of the liquid medium is water [1].

CWSF is a dispersed system of the following composition, %: 40 - 70 coal of up to 200 (500) m; 30 - 60 of water; <1 reagent plasticizer. CWSF has a flash point of 450 - 650 ° C; Combustion temperature 950 - 1050 ° C; net calorific value of 2000 - 4800 kcal / kg (depending on the type of coal, ash and moisture); has all the technological properties of liquid fuels (transport to road and rail tankers via pipelines, tankers and tankers, storage in closed containers); retains its properties during long-term storage and transportation; explosion and fire [2].

CWSF its characteristics and consumer properties have advantages over conventional fuels (coal, diesel fuel cost): suspension of all fuel by 10-20% above the main component - coal and consumer properties similar to liquid fuels. At the same time, the cost of CWSF is 1200 RUB / ton [3].

Coal water slurry fuel can be a substitute for fuel oil, boiler modernization in this case is minimal, but its production by traditional technologies is possible on special plants and is associated with the creation of the structure of distribution, storage and transport of fuel. Traditional technology of water-coal fuel has high energy and metal costs and fuel has several drawbacks: the stability of the entire fuel system from 20 to 60 days, the main dimensions of solids are in the range of 60-250 microns, technological schemes to create bimodal complicate production and consumption increase the cost of CWSF. Currently, the use of artificial coal-water fuel is common in a number of countries: Japan, China, Italy, and in some European countries [4, 5].

Characteristics of the research object

At the current level of production CWSF should be based on new principles, which would allow to receive fuel with less power, higher quality, with a greater proportion of decentralization of production, which in our case due to the reduction in the cost of transportation and storage of CWSF. Should be substantially increased efficiency coal grinding devices.

One of the characteristics of combustion CWSF - parallel flow of combustion processes of solid particles from the surface of the fuel droplets and the evaporation of moisture contained in these droplets. That is what determines the high activity of the organic mass burn fuel and causes ecological purity of its combustion. CWSF can be prepared on the basis of coal of all brands, including the coal with a lot of ash. When burning CWSF fly ash agglomerates, resulting particulate emissions are reduced by 60-80% [6].

At present, the existing methods for the preparation of coal-water fuels are based on the mechanical stress on components with the addition of a plasticizer CWSF for homogenization. Known plasticizers are phenol and naphthalene waste production, pairs of which have carcinogenic activity and can destroy red blood cells in human blood.

In the laboratory, "Plasma Physics and Plasma Technology" experimented with obtaining of CWSF by Plasma and electric discharge methods. These methods difers from other methods by sparing of plasticizer, using the energy of electric discharge and plasma energy. In this

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work, we used D-grade coal of Tugnuisky coal mine, whose characteristics are shown in Tables 1, 2 and 3.

Table-1. Characteristics of coal.

Q-net calorific value, kcal / kg	W-wet, %	A^a-ash content, %	V-volatile gases, %
5500	14,0	29	45

Table-2. Organic mass of coal.

Organic mass, %				
C	O	H	N	S
74,2	14,5	5,27	1,43	0,37

Table-3. Mineral mass of coal.

Mineral mass, %						
SiO_2	Al_2O_3	$Fe_2 O_3$	CaO	MgO	K_2O	Na_2O
52,3	26,5	5,5	4,3	1,4	1,3	0,5

Survey methodology and equipment

During the experiment by the electric discharge method coal dust with fraction of 100 microns falls in the container, was stirred with water and then the resulting mixture was treated with an electrical shock. After the voltage leaking process of electrochemical treatment of the mixture at a constant current in the process was observed gas emissions. Electric discharge occurs between the internal electrode- 3 and the container body. For the uniform electrochemical treatment of coal-water slurry an internal electrode is formed in a spherical shape and uniformly rotates by the electric motor- 2 (Figure-1).

Analysis of samples showed that the ash content decreased from 29 to 18%, due to the evolution of gases oxides S, N and O. This implies that the action of the energy discharge is a partial disintegration of the coal burning sulfur contained in it, as well as local expansion of the water molecule with ionized form atomic hydrogen ions and oxygen. Ash content was determined by the method of slow digestion of coal (national standard 6383-52). [7]

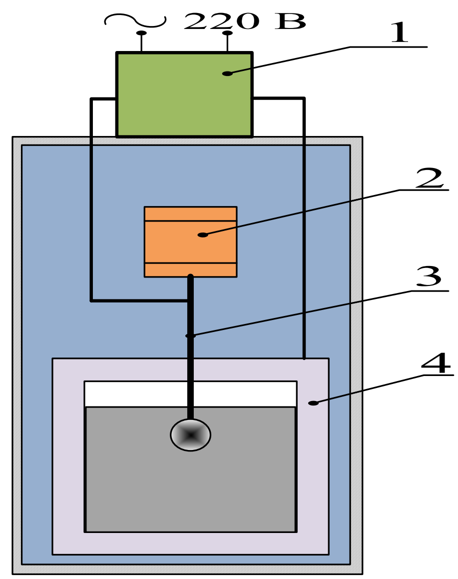

Figure-1. Experimental setup for the preparation of coal-water fuel electric discharge method: 1- laboratory autotransformer; 2 - motor; 3-electrode-mixer; 4 capacity with coal-water slurry.

As a result of both experiments was obtained from the coal-water slurry of coal Tugnuisky fraction of 0.1 mm with a ratio of the solid and liquid phase 50/50 and had sedimentation stability for 2 days, ie retains a uniform distribution of particles throughout the volume of the slurry.

During the experiment by the plasma method plasma modular reactor was used. The coal dust fraction of 100 microns falls in the reactor-1 with the rotating inside the electric arc and then treated light particles of coal imposed with exhaust gases, elute and settled at the bottom of the Sprinker-14 and the cyclone 15 (Figure 2).

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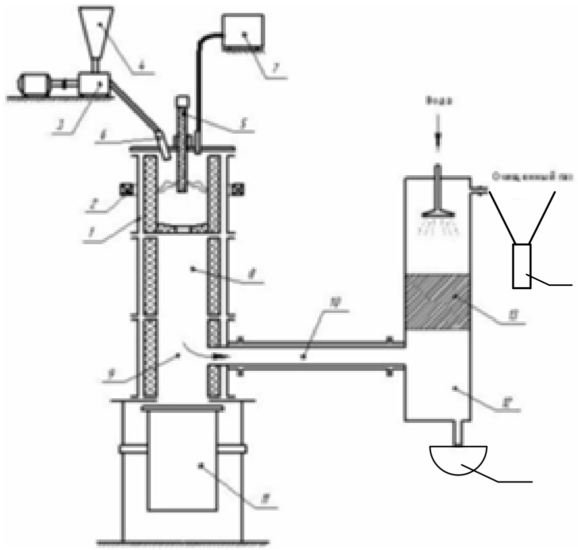

Figure-2. Plasma Modular Reactor.

1 - reactor; 2 - magnetic coil; 3 - dispenser; 4 - bunker raw materials; 5 - cathode; 6 - ejector; 7 - steam generator; 8 - Camera muffle; 9 - separating chamber; 10 - gas pipe; 11 - a collection of solid; 12 - scrubber; 13 - Filter; 14 - Sprinkler.; Cyclone- 15

The structure and chemical composition of the samples before and after treatment were investigated in the center for collective use "Progress" in a scanning electron microscope JSM-6510LV JEOL.

DISCUSSION OF RESEARCH RESULTS

The research results are shown in Figures (3, 4, 5, 6). The micrographs shows that the surface area of samples after the processing is much more dispersed (crushed) than the original sample. This indicates that the suspensions after the treatment are favorable for the mechanical stability of the structure (see Figure. 4, 5, 6). Dispersing of the sample in Figure 6 is pronounced.

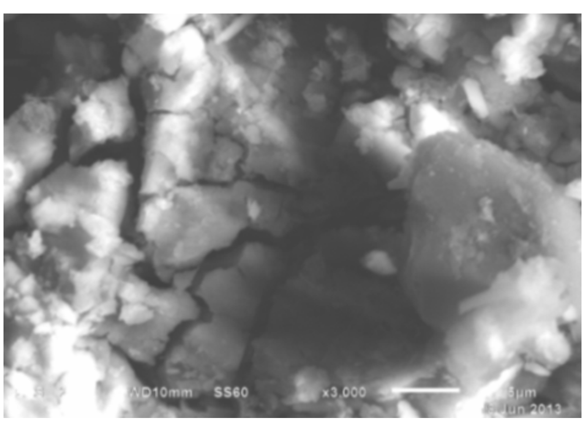

Figure-3. Coal before treatment.

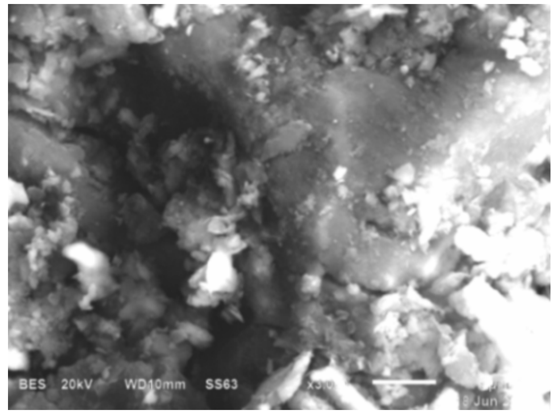

Figure-4. Coal after treatment by the electric discharge method.

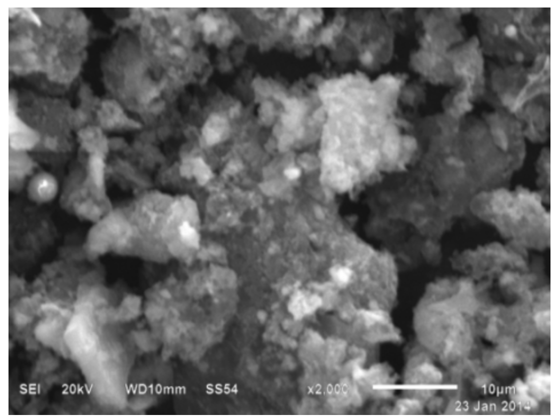

Figure-5. Coal after treatment by the plasma method (samples in the cyclone).

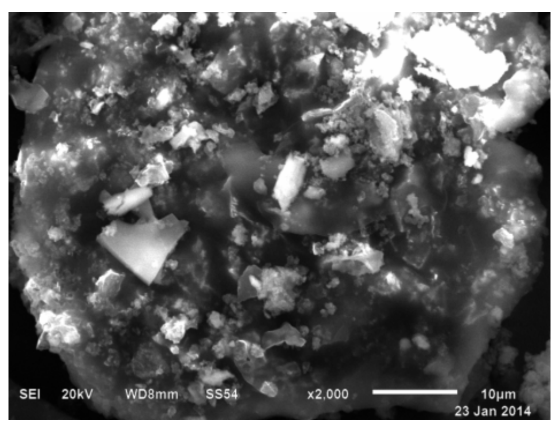

Figure-6. Coal after treatment by the plasma method (samples in the scrubber).

Elemental analysis shows that that after the treatment, the amount of sulfur and oxygen is significantly reduced, relative to the parameters of the original coal, and carbon content increased, which is a positive result. (Table-4).

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Table-4. Results of elemental analysis.

Figure	Element	Weight, %
Figure-3. Coal before treatment	C	42.06
	O	38.82
	Mg	0.22
	Al	3.72
	Si	5.68
	S	1.93
	Ca	0.55
	Fe	5.56
	Cu	0.88
	Zn	0.57
	Total	100.00
Figure-4. Coal after treatment by the electric discharge method	C	71.56
	O	22.17
	Al	0.58
	Si	0.93
	S	0.76
	Fe	0.36
	Cu	0.41
	Zn	0.44
	Zr	2.80
	Total	100.00
Figure- 5. Coal after treatment by the plasma method (samples in the cyclone)	C	72.41
	O	21.31
	Na	0.07
	Mg	0.08
	Al	1.34
	Si	3.03
	S	0.30
	K	0.11
	Ca0	0.29
	Ti	0.06
	Fe	0.41
	Cu	0.38
	Zn	0.20
	Total	100.0
Figure-6. Coal after treatment by the plasma method (samples in the scrubber)	C	67.05
	O	25.23
	Na	0.18
	Mg	0.08
	Al	0.85
	Si	1.78
	S	1.17
	Cl	0.13
	K	0.08
	Ca	0.16
	Ti	0.01
	Fe	2.41
	Cu	0.47
	Zn	0.41
	Total	100.0

CONCLUSIONS

From the tables and figures it becomes clear that plasma method largely reduces oxygen and sulfur than the electric discharge method, in the result of more intense thermal and chemical treatment.

A further area of research is to identify the composition of carbon nanoparticles in coal-water slurry fuel obtained by both methods, as well as providing a suspension of more sedimentary stability (up to 5 days).

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