

UDC 53.06; 53.043

INFLUENCE OF ELECTRIC HYDROIMPULSE PROCESSING ON PROPERTIES OF WATERCOAL MIXTURES

K. Kusaiynov, S.E. Sakipova, G.K. Alpysova, K.E. Akhmerova

The Karaganda State University named after E.A. Buketov, Karaganda, Kazakhstan, kappas090108@mail.ru

In work influence of electrohydroimpulse processing on structure and quality of watercoal mixtures is investigated. By means of a linearization of the nonlinear equation of an electrodischarge circuit the estimation of parameters of the category is carried out. Change of properties of a watercoal mixture, including, moistness, cinderness, heat of combustion, after electrohydroimpulse processing is studied. It is shown that the given method allows combining process of crushing of coal and receiving of watercoal mixtures with set of thermophysical properties.

Keywords: electrohydroimpulse processing, watercoal mixtures, electrodischarge circuit, thermophysical properties.

Introduction

Development of the industry and technologies puts a problem of creation of the effective technologies which working out is impossible without use of new materials with the set or steered properties. Modern achievements in the field of materials technology show that now it has become possible to forecast of properties of new combinations, durability of constructional elements even in difficult operation conditions. Use of the electric discharge in the water, known as electrohydraulic effect, as a source of a high pressure and temperature opens essentially new prospects before materials technology. Arising shock waves allow to extend limits of used pressure to ten millions of atmospheres, and temperatures - to tens thousand degrees.

The physical phenomena which accompany such discharge, are on a meeting point of physic of low temperature plasma, physicists of high densities of energy, thermophysics of liquids and electrodynamics [1-2]. Practice shows that electroimpulse methods of processing of materials allow to process firm, difficultly deformable materials, intensify many technological processes, influence structural changes in materials. Work is devoted to studying of influence of elektrohydroimpulse processing on properties of processed coal mixtures.

Equipment and methods of the experiment

Electrohydraulic installation consists of the control board, the highvoltage generator of pulse pressure switching the devices with the safety system and the working port where crushing of coal powders is made. In installation there is a conical chamber in volume $1,5 \cdot 10^{-3} \text{ m}^3$ in which the linear system of electrodes is installed. The positive electrode is located vertically, and the bottom of the metal chamber serves as a negative electrode.

The energy accumulated in the condenser is transferred by the help of the switching device to a working interval in a liquid, creates the electrohydraulic discharge. The form and duration of the pulse current which is passing on a discharge circuit of the generator, depends on parameters of charging and discharging circuits. The generator of pulse currents is characterized by an output voltage up to $(50 \pm 0.1) \cdot 10^3 \text{ V}$ and a current $(0.1 \pm 0.05) \text{ A}$. Depending on parameters of a circuit duration of the electric discharge in a liquid can change from 10^{-5} to 10^{-3} s .

In the carried out experiments influence of electric parameters of a discharge circuit on duration of impulses was studied at various values of capacity C of accumulators of energy – condensers, at several values of interelectrode distance l in a steered discharge switch. For investigation of dynamics of signals the digital oscillograph Velleman PCS-500 switched with the computer with corresponding software PC Lab-2000 is used. As a working environment water coal mixtures (WCM), subjected to electrohydraulic processing are used.

As the discharge port is a consumer of energy and simultaneously an uncontrollable nonlinear element of an electrodischarge circuit, its electric characteristics depend on parameters of a circuit and influence

these parameters, providing an interconsistency of the phenomena [4]. For receiving of possibility of steering the parameters of process for the purpose of the most effective transformation of energy it was necessary to establish functional connection between characteristics of a discharge circuit and plasma parameters.

While formation of the electric discharge in a liquid energy allocation occurs during enough short time interval. The powerful high-voltage electric impulse with abrupt front causes the various physical phenomena, such as occurrence of ultrahigh pulse hydraulic pressure, electromagnetic emission in a wide waveband, the cavitation phenomena. All these factors render various physical and chemical influences on a liquid and disperse particles being in it. Directly the water environment, in which there is a high-voltage electric discharge, is the transformer of the energy allocated in the port of the discharge.

For calculation of parameters of a discharge circuit

The thermodynamic analysis of processes while breakdown a liquid both at predominant and dominant stages shows the presence of strong dependence of characteristics on specific water electric conductivity. In [5] by means of the methods of similarity inversely proportional dependence of duration predominant stages of breakdown from intensity of a field and thermophysical parameters and liquid temperature has been established, i.e. resistance of the port of the discharge is nonlinear one. If to consider that at increase of capacity of the discharge resistance is in inverse proportion to a current i , then the equation of a discharge circuit can be written down as follows:

$$\frac{di^2}{dt^2} + (1 - \mu) \frac{R}{L} \frac{di}{dt} + \frac{1}{LC} i = 0, \quad (1)$$

where L, C - are inductivity and capacity, R - active resistance, μ - parameter of a discharge circuit.

The conversion of the nonlinear differential equation by Krylov-Bogolyubov's method allows to approximate it to its equivalent linear equation with constant factors with a margin error of order $\approx \mu^2$. As active resistance of a discharge circuit R its value at the moment of a maximum current and capacity is accepted in this case. The linearization of characteristics of the discharge allows to use corresponding correlations of the linear discharge for their calculation. Then for calculation of amplitude values of time t , a pulse current i , power N and a steepness γ we will receive:

$$t_m = k_t \cdot \sqrt{LC} \quad (2)$$

$$i_m = k_i \cdot U_0 \cdot \sqrt{\frac{C}{L}} = k_i \cdot q_0 \cdot \omega_0 \quad (3)$$

$$N_m = k_n \cdot U_0^2 \cdot \sqrt{\frac{C}{L}} = k_n \cdot W_0 \cdot \omega_0 \quad (4)$$

$$\gamma_m = k_\gamma \cdot U_0^2 \cdot \frac{1}{L} = 2k_\gamma \cdot W_0 \cdot \omega_0^2 \quad (5)$$

where q_0, W_0 - an initial charge and energy of a circuit, ω_0 - own frequency of a discharge circuit, k_t, k_i, k_n, k_γ - the dimensionless factors depending on relative resistance of a circuit and a mode of the discharge.

The stable characteristic of the discharge is the average steepness of power at an active stage which defines intensity of formation of a force field and is the power characteristic of the discharge. Resistance of the port of the discharge at the moment of a maximum current depends both on discharge parameters and characteristics of expansion of the port of the discharge in a liquid. Considering a constancy of temperature of plasma in period of power increase, for calculation the resistance in [6] the following value dependence on length of the port of the category is offered:

$$R = B \cdot \frac{\omega_0^2 \cdot l^{2,25}}{\gamma^{1,25}}, \quad (6)$$

where B - is an empirical constant.

The experiments show that at accuracy of measurement of electric parameters of (3÷5)% of a deviation of amplitude of a discharge current from linear one aren't marked up to the value $R = 5R_{kp}$. Thus, nonlinearity of parameters of a discharge circuit affects basically the pressure form on a discharge interval and very poorly influences a current and power of the charge.

Results and discussion

In connection with increase of a share of low-grade coals in world fuel energetic balance, the working out and introduction of new power saving up technologies of processing and decrease of harmful dustgaseous blowouts at these burning are of great importance. This point in question decision gets a special urgency for Kazakhstan possessing rich deposits of low-grade coal [3]. Application in the industry and energetics of low-grade coals without preliminary processing is not expedient, but improvement of consumer properties, as well as manufacture of new materials and alternative fuel, is possible only after technological processing of raw products.

Investigations on working out of technology of reception and use of watercoal suspension (WCS) or water coal fuel (WCF) are actual [3]. Thus coal is split up and crushed into tiny fractions. Known methods of coal processing in a mechanical way or vibrowave method on operating plants aren't effective, as being labor-consuming, demand the great expenses of energy and aren't non-polluting. The method of electrohydraulic processing of water suspensions of minerals and coals used in given work allows to receive a powder (mixture) with the certain sizes of firm fractions quickly and with the minimum expenses, to change its structure and characteristics, and on its basis to create materials with the set properties, and also simultaneously to lower environmental contamination. Owing to small compressibility of water the blowout of energy as a result of the electric discharge leads to quick growth of pressure. At passage of a powerful impulse to the liquid heterogeneous environment the voltage failure accompanied by hydraulic blow which splits up is created and crushes firm fractions. The electric hydropulse mode of crushing allows to regulate granulometric structure of a ready product with the raised selectivity. For crushing coals definition of time of processing, optimum value of interelectrode distance and corresponding value of energy of the category on the switching device [6] was important. Experiments were carried out in water mixtures of coal powders of various sorts.

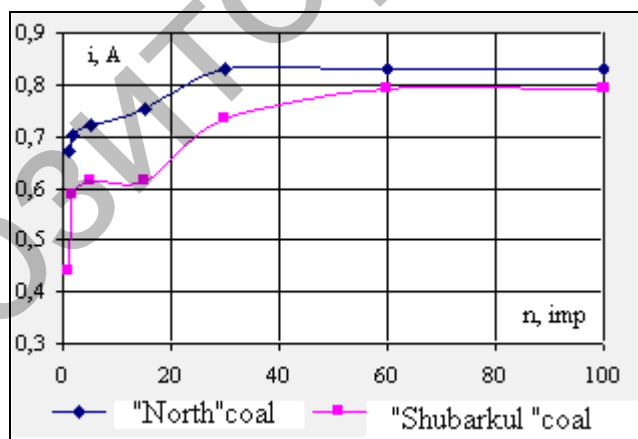


Fig.1. Dependence of amplitude of a pulse current on quantity of discharges

In figure 1 dependences of change of amplitude of a pulse current in water coal suspension from quantity of electrohydraulic impulses are presented. From the schedule it is seen that the amplitude of a current increases in process of processing, hence, energy losses decrease for formation of the discharge port in an interelectrode interval in a water coal mixture. However, amplitude increase becomes more slowly, and after 50 impulses the value of an amplitude current practically doesn't change. In the second series of experiences change of properties of watercoal suspension under the influence of an electroexplosion shock wave, in particular the change of electric conductivity of the investigated environment depending on initial coarseness of coal particles was studied.

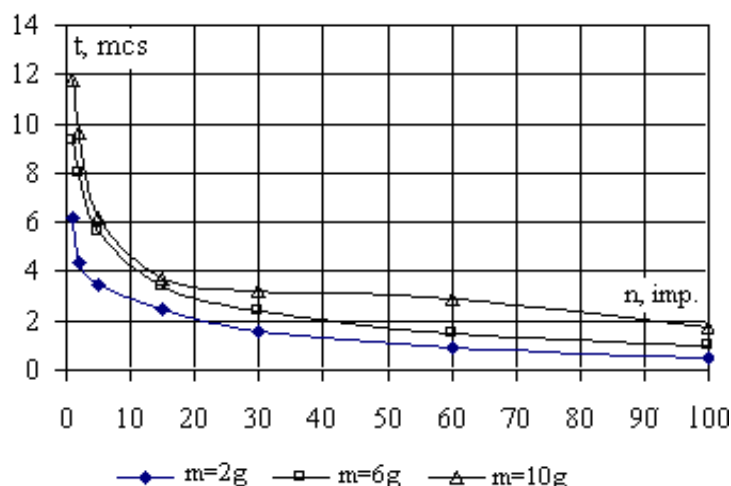


Fig.2. Dependence of time of a predischarge stage on quantity of pulse discharges

In figure 2 the schedule of dependence of time of breakdown from quantity of discharges in the water coal environment with diffractions various initial coarseness, i.e. with firm parts of various scales at the beginning of the processing is resulted. As a result of processing of the experiment data it is established that essential influence on conductivity (inverse to resistance) the heterogeneous environment makes initial coarseness of firm particles. At the first stages of electrohydraulic influence when the size of firm parts in the heterogeneous environment fluctuates in the big intervals, the time of a predischarge stage is maximum. Accordingly the size of amplitude current is minimum, and then in process of charge accumulation it sharply increases that basically will be coordinated with calculating dependences (2) - (5).

Table 1. Change of properties of coal before processing and after processing

The investigated properties	Before processing	After processing
Mass fraction of moistness, %	7,5	8,56
Cinderness, %	7,7	1,52
Mass fraction of sulfur, %	0,54	0,58
The higher warmth of combustion, kcal/kg	7354	7162
Output of flying substances, %	43,1	43,85

During the experiments influence of parameters of electrohydraulic blow on character of crushing of coal fractions is defined. Processing of various coals is carried out at various capacities of the condenser battery. It is established that in optimum parameters of electrohydraulic processing, at which percentage small disperse fractions with in the sizes $d \leq 0,7mm$ is maximum, are values of an operating voltage on the energy accumulator $(20 \div 25) \cdot 10^3$ V at battery capacity of condensers $0,5 \cdot 10^{-6}$ F [7]. The electrohydraulic method at the specified parameters is appropriate production conditions and provides intensive crushing of coal particles.

Elektrohydropulse processing influences not only electrophysical properties of coal mixtures, but changes thermophysical properties as well. In the table and in Fig.3 the data on some parameters of a coal powder before processing is presented.

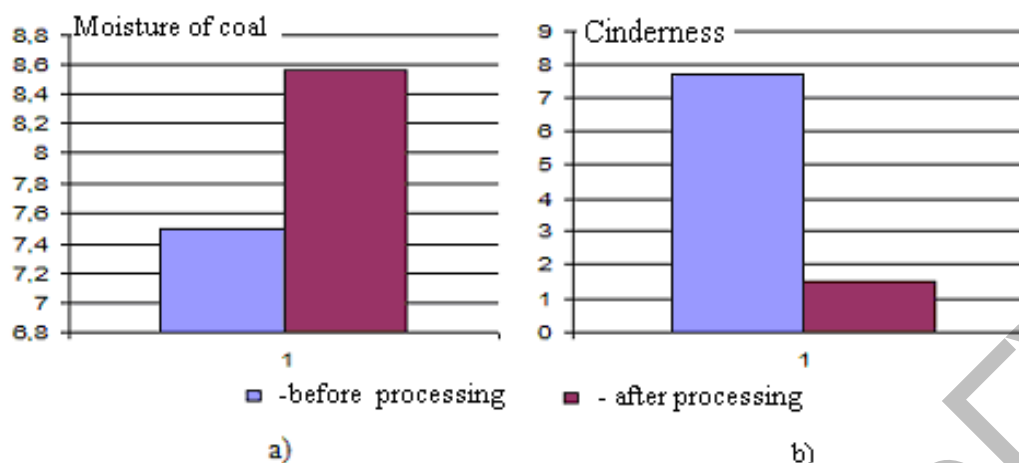


Fig. 3. The diagram of coal properties before and after processing: a – moistness; b – cindersness

As it is clear from the table, after electrohydraulic processing moistness of coal increases, and cindersness decreases. The given results are received for coal powders of ekibastuz coalfield. Hence, electrohydraulic processing allows to intensify process of burning of watercoal mixtures and simultaneously it is essential to improve ecological compatibility owing to cindersness decrease almost in 3 times.

Conclusions

The research of laws of development of the pulse, electric discharge in the multicomponent environment represents theoretical and practical interest owing to wide use of electrodischarge technologies at processing of products and in processes of manufacture of new materials. In the carried out experiments the optimum parameters of electric hydropulse technologies of water coal mixtures are defined. Experiments show that the amplitude of a pulse current, and accordingly, pressure of a shock wave grows with increase in pressure of breakdown, which depends on the accumulated charge. Besides, the pressure size is influenced by degree «fullness» - the increase in volume of air space in a working part leads to that the pressure impulse aspires in its form to a pressure impulse in a clear water, i.e. it compensates influence of a firm disperse phase. It is established that nonlinearity of parameters of a discharge circuit affects basically the pressure form on a discharge interval and very poorly influences a current and power of the discharge. In engineering calculations it is possible to use the simplified formulas (2) - (6).

Change of thermophysical properties of watercoal suspension under the influence of an electroexplosion shock wave is studied. The electrohydraulic method allows to change some physical properties and quality of a watercoal mixture, and to combine process of crushing of coal and reception of these mixtures as the electric discharge is made in the water environment as well.

6. Gavrilov G.N., Gorovenko G.G., Malyushevsky P.P., Ryabinin A.G. Discharged-pulsed technology of the processing the mineral ambiences. – Kyiv: Nauk.dumka.-1979.-164p.
7. Semkin B.V., Usov A.F., Kurets V.I. The bases of electro-pulsed destruction of materials. / St. Petersburg: Nauka, 1995.-276p.
8. Suharnikov Yu. The waste of stone coal flotation as energy fuel. //Kazakhstan Industry. - 2002, N 10.– P.28-31.
9. Usmanov G.Z., Lopatin V.V., Noskov M.D., Cheglovkov A.A. Mathematical modeling of the frail destruction material under electric discharge. // Vestnik of the Tomsk State University. - 2009, N1(5) - P.112-121.
10. Vitevskiy V.I. The Linearization of the features of the electric discharge category in liquids. / Scientific reports. - Kyiv: Nauk.dumka.-1979. - P.13-14.
11. Kusainov K. Satybaldin N.M., Obidina A.S., Tsoi R.I. About electro-hydraulic method of the reception water-coal mixture. // Vestnik of the KarSU.– Karaganda , 2004, №2. - P.54-61.
12. Kusainov K., Sakipova S.E., Kurmasheva K.E. The Optimization to technologies of the reception water-coal fuel on base electro-hydraulic pulsed processing low - qualitative coal. // Materials of the 3-rd Intern.conf. «Deformation and destruction material and nanotechnologies». - M.:Interkontakt Nauka, 2009. - P.152-153.