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Coal pulverization by electric pulse method for water-coal fuel

In the article describes the electrohydraulic method as a source of high energy concentration for the disintegration of the components of water-coal fuel in an aqueous medium under the action of pulsed discharges. The proposed method of grinding coal is based on the use of pulsed shock wave energy resulting from a spark electric discharge in a liquid. The essence and distinctive feature of the proposed technology is that the processing of the material using the energy of the shock wave released with electrohydraulic action allows to obtain a quickly crushed product of a given size. The degree of grinding of the material on the dependence of the electrical and geometric parameters of the installation is determined. The optimal parameters of the capacitance of capacitor banks, voltage of pulse discharges, number of pulse discharges and forming gap distance are proposed. The presented results of laboratory tests at different temperature mode, which proves that the grinding of coal by electric discharge method does not require additional cooling, since the processing process is carried out in a liquid medium. The main working element in the electric pulse processing is a spark discharge, the resulting product is not contaminated with the materials of grinding bodies, characteristic of the traditional mechanical method.

Keywords: coal, grinding, spark discharge, discharge voltage, electric pulse method.

Introduction

Among alternative fuels, the so-called water-coal fuel has good prospects. Water-coal fuel is a dispersed fuel system consisting of finely ground (40–500) microns) coal (55–70 % of the composition), water of any quality, including mine water and industrial effluent water (30–45 % of the composition) and reagent-plasticizer. The presence of water in the composition of coal fuel provides a reduction of harmful emissions into the atmosphere and turns coal into an explosion-proof material. The use of water-coal fuel has a number of environmental, technological and economic advantages. Also one of the main advantages are safety at all stages of production, reduction of harmful impurities in the atmosphere, the possibility of using it like liquid fuel and full mechanization and automation of the process, the possibility of using coal of any brands and reducing the cost by 2 or more times. The energy efficiency of such fuel depends on the initial preparation of coal, namely its grinding. In this regard, it is necessary to improve the quality of coal grinding [1, 2].

Grinding coal for water-coal fuel is the basic task that must be solved in the production process. Rheological properties and stability of the combustion process in direct proportion depends on the stability of the grinding process of the coal with the specified parameters and strict adherence to the concentrations of excipients. For grinding coal, used mechanical crushers and mills of various types. Until recently, the water-coal fuel is received with the use of these grinders. Mechanical mills can grind coal to a pulverized state, but have disadvantages in the form of bulkiness and complexity of equipment, significant specific power consumption, as well as insufficient efficiency in the processing of high-strength items. There are also difficulties in grinding wet ash coals, which merge and are compressed under the grinding organs, which leads to a deterioration of the grinding [3–5].

In this regard, the grinding of coal under the influence of pulsed discharges in a liquid medium to obtain the necessary product of water-coal fuel was studied.

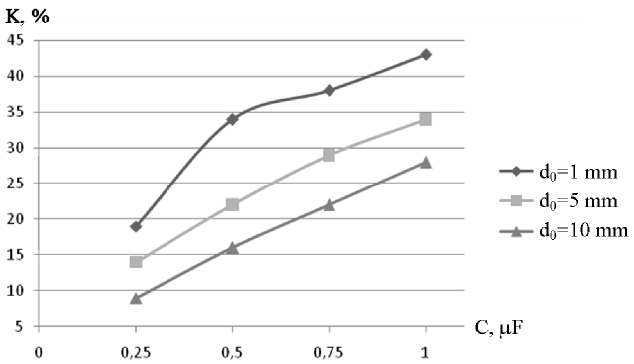
The essence of the electrohydraulic method consists in the fact that when a specially formed pulsed electric (spark, brush and other forms) discharge is carried out inside a volume of liquid located in an open or closed vessel, super-high hydraulic pressures arise around the zone of its formation, capable of performing useful mechanical work and accompanied by a complex of physical and chemical phenomena [6, 7].

The technological scheme of coal grinding includes a power source, a capacitor Bank as a storage of electric energy, forming a spark gap, a working cell. The initial diameter of the coal particles in the tests averaged d_0= 1 mm, 5 mm, 10 mm, the diameter of the resulting product d = 70 µm.

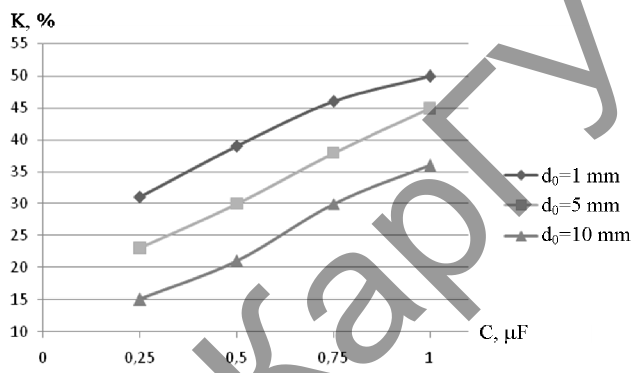
Results and its discussion

Laboratory work on coal crushing is performed depending on the basic electrical and geometric parameters of the electrohydraulic installation:

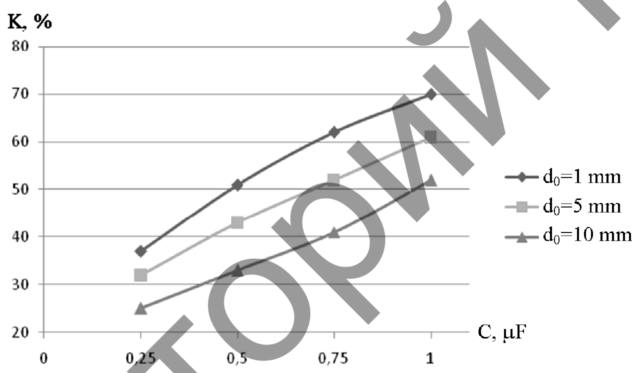
– capacitor bank capacity — 0.25 UF÷1 UF (Fig. 1);
– pulse discharge voltage — 20 kV÷32 kV (Fig. 2);
– number of pulse discharges — 300–2000;
– the distance of the forming gap is 7 mm÷11 mm.



a) d = 70 μm; l = 7 mm; N = 600



b) d = 70 μm; l = 9 mm; N = 600



c) d = 70 μm; l = 11 mm; N = 600

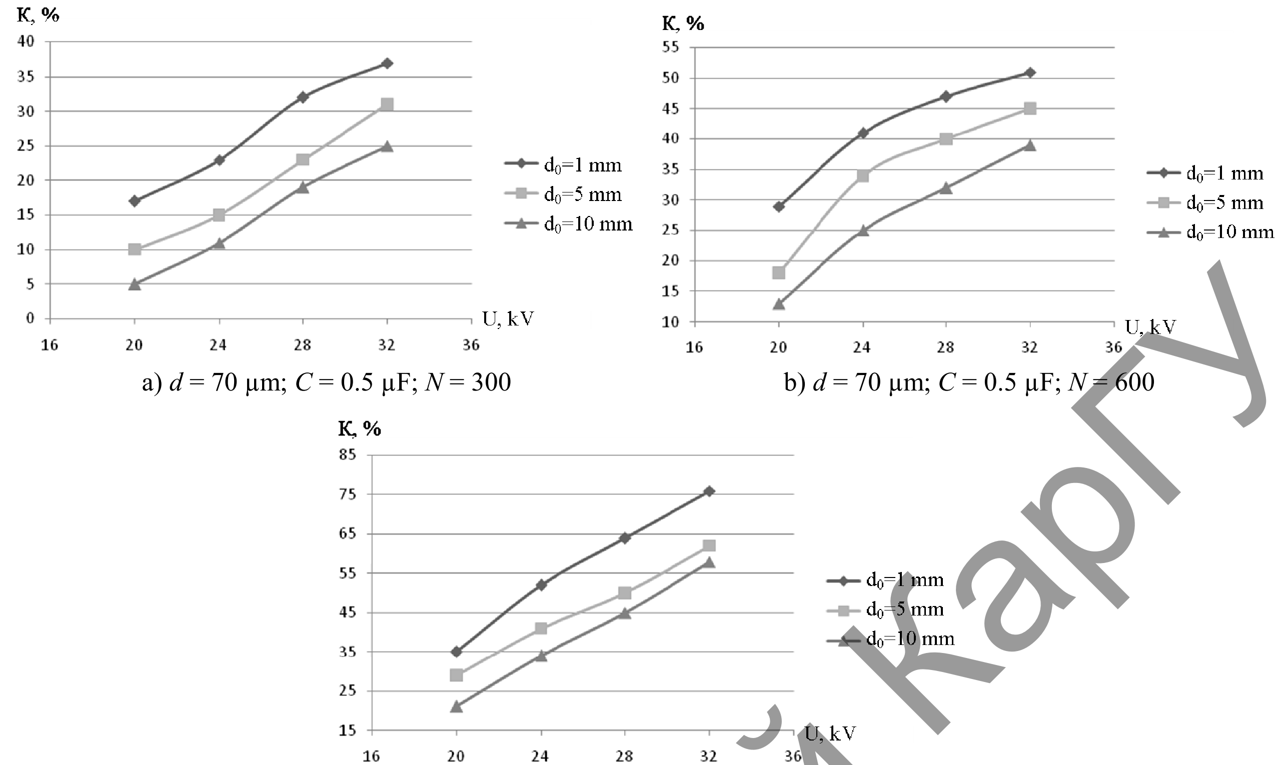
Figure 1. The dependence of the degree of grinding of coal on the capacity of the capacitor bank

The results of the dependence of the degree of coal grinding on the capacitance of the capacitor Bank are obtained at constant values of the discharge voltage and the number of discharges (U = 24 kV, N = 600), and with an increase in the forming interval of the electrohydraulic installation from 7 mm to 11 mm.

Grinding of coal depending on the discharge voltage was carried out at the value of the capacitance of the capacitor Bank C = 0.5 μF and at different values of the number of discharges of the number of discharges (N = 300÷600). From the results obtained, it can be seen that with increasing electrical and geometric parameters, the degree of grinding of coal increases. The following values are selected as effective parameters of the installation: U = 24÷28 kV, C = 0.5 μF, l = 9 mm, N = 600.

The following studies were devoted to the study of changes in the temperature of the medium in the process of grinding coal during the passage of a pulse discharge in a liquid medium.

This is due to the fact that in traditional methods before grinding coal is dried to a temperature of 70–85 ºC. In mechanical mills, as a result of friction between the crushing parts and the mill wall, heat is generated, which causes the temperature of the dried untreated coal to rise by 20 ºC. Thus, the temperature of the pre-cooled untreated coal again reaches the permissible level of about 60 ºC. To cool the crushed particles to a temperature below 60 ºC, cooling air is passed through an air-flow grinding mill at a temperature below the temperature of dried unprocessed coal [8].



a) d = 70 μm; C = 0.5 μF; N = 300

b) d = 70 μm; C = 0.5 μF; N = 600

c) d = 70 μm; C = 0.5 μF; N = 900

Figure 2. The dependence of the degree of grinding of coal from the voltage discharge

The number of pulsed discharges increased from 400 to 2000 when the temperature of the raw material changed during coal crushing by electrohydraulic method (Fig. 3). According to the obtained results it was observed that increasing the number of impulse discharges from 400 to 2000 maximum temperature limit hydrocarbon fuel was 55 ^{0}C. This suggests that grinding of coal electrohydraulic method does not require additional cooling, as the process takes place in a liquid medium.

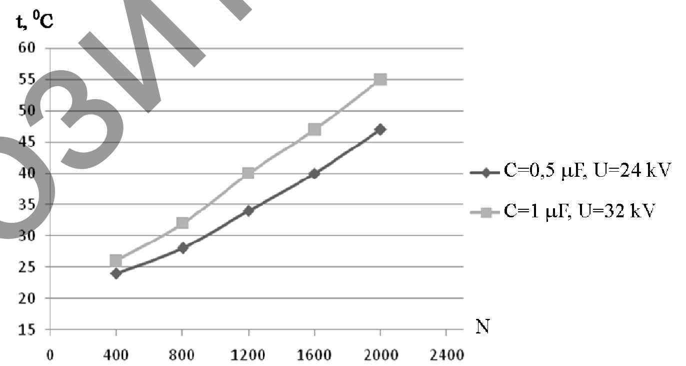


Figure 3. The dependence of the temperature of wet coal in the working cell on the number of pulse discharge

Conclusion

The use of electrohydraulic method to obtain the necessary product for water-coal fuel shows the effectiveness of the method. The efficiency depends on the capacitance of the capacitor Bank, the pulse discharge voltage and the number of pulse discharge. The results of processing coal pulsed discharges in a liquid medium, shows the rationality of the electrohydraulic method for obtaining water-coal fuel.

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Сулы-көмірлі отын үшін көмірді электримпульсті әдісімен ұсақтау

Мақалада импульстік разрядтардың әсерімен сулы ортада сулы-көмірлі отынның компоненттерін дезинтеграциялауға арналған энергияның жоғары концентрациясының көзі ретінде электрогидравликалық әдіс сипатталған. Көмірді ұсақтаудың ұсынылған тәсілі сұйықтықта ұшқынды электр разрядының нәтижесінде пайда болатын импульстік соққы толқынның энергиясын пайдалануға негізделген. Ұсынылған технологияның мәні мен ерекшелігі — электрогидравликалық әсер ету кезінде соққы толқынның энергиясын пайдалану арқылы материалды өңдеуде белгілі бір мөлшерде тез ұсақталған өнімді алуға мүмкіндік береді. Қондырғының электрлік және геометриялық параметрлерінің тәуелділігінен материалды ұсақтау дәрежесі анықталды. Конденсаторлық батареялар сыйымдылығының оңтайлы параметрлері, импульстік разрядтардың кернеуі, импульстік разрядтардың саны және қалыптастырушы аралықтың арақашықтығы көрсетілген. Зертханалық зерттеулердің нәтижелері әртүрлі температура режимдерінде ұсынылған, бұл көмірді электрлік разряд әдісімен ұнтақтау қосымша салқындатуды қажет етпейді, себебі өңдеу процесі сұйық ортада орындалады. Электримпульсті өңдеу кезінде негізгі жұмыс элементі ұшқындық разряд болып табылады, алынған өнім дәстүрлі механикалық әдістерге тән ұнтақталған денелердің материалдарымен ластанбайды.

Кілт сөздер: көмір, ұнтақтау, ұшқынды разряд, разряд кернеуі, электроимпульстік әдіс.

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Измельчение угля электроимпульсным способом для водоугольного топлива

В статье описан электрогидравлический способ как источник высокой концентрации энергии для дезинтеграции компонентов водоугольного топлива в водной среде под действием импульсных разрядов. Предлагаемый способ измельчения угля основан на использовании энергии импульсной ударной волны, возникающей в результате искрового электрического разряда в жидкости. Сущность и отличительная особенность предлагаемой технологии в том, что обработка материала с использованием энергии ударной волны, выделяемой при электрогидравлическом воздействии, позволяет получить быстро измельченный продукт заданной крупности. Определена степень измельчения материала в зависимости от электрических и геометрических параметров установки. Предложены оптимальные параметры емкости конденсаторной батареи, напряжения импульсных разрядов, количество импульсных разрядов и расстояние формирующего промежутка. Представлены результаты лабораторных испытаний при различных температурных режимах, которые доказывают, что измельчение угля электроразрядным способом не требует дополнительного охлаждения, так как процесс обработки осуществляется в жидкой среде. Основным рабочим элементом при электроимпульсной обработке является искровой разряд, полученный продукт не загрязняется материалами мелющих тел, свойственных традиционным механическим методам.

Ключевые слова: уголь, измельчение, искровой разряд, напряжение разряда, электроимпульсный метод.

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