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Justification of Rational Parameters of Briquetting Using Mechanic Activation Techniques

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Abstract. The paper illustrates results of development of technology and compositions of briquetting substandard lignite waste with the use of tar as a binder, modified with mechanically activated organic-mineral fillers. The influence of highly disperse additives and technological briquetting regimes on the structure formation and the qualitative characteristics of fuel brown coal briquettes is considered.

At present, there is no consistent scientifically sound approach to the selection of effective binding and technological regulations for the production of coal briquettes on the basis of the Kangalassi, Kirov and Kempendyai deposits. Therefore, the development of a technology for the production of briquetted brown coal fuel is rather relevant and has a great practical perspective for solving the fuel problem in remote areas of the North with unsatisfactory transport scheme: there are no traditional fuels and the import is impeded. The current briquetting technologies of both Russian and foreign production do not fully satisfy the requirements of consumers, like the cost and technical requirements for use in areas with cold climate [1-2]. The feasibility of the research is due to the significant need for cheap sorted fuel for domestic needs, as well as the accumulation, in the coal regions, of millions of tons of energy-bearing coal slimes that occupy vast areas and, at the same time, can serve as raw materials for the production of fuel briquettes.

The tar from oil refining serves as a binder that improves the quality and thermotechnical characteristics of the fuel. Its use is economically advantageous due to low prime cost and affordability; it requires significantly lower transportation costs than bitumen does. The modification of structurally active additives of tar is applied to improve its quality. Dry sapropel from Lake Bolshaya Chabyda and brown coals of the Kangalassi deposit are used as natural sorbents.

A prerequisite for the use of dispersed substances of organic and mineral origin as modifying additives in the filling of binder in the technology of brown coal briquetting, in addition to an extensive raw material base and low cost, are their specific properties determined by increased specific surface area, porosity, and high adsorption characteristics.

The general technological scheme for obtaining brown coal briquettes consists of the following operations: charge preparation, pressing, heat treatment and cooling. Before being imported into the binder, the additives are pre-dried at 110 °C in order to remove some of the residual moisture and subjected to mechanical activation on an AGO-2 planetary mill for two minutes to achieve greater efficiency. During mechanical activation, the particles are converted into a highly excited state characterized by elevated surface energy values, the degree of ordering of the crystal structure is destroyed, defects appear, and a transition to a metastable, nonequilibrium particle state occurs simultaneously with the dispersion and increase of the specific surface of the particles [3-4].

Mixture compositions with different contents of brown coal and a binder composition based on organic-mineral additives are prepared by a technique that includes charge preparation consisting of several operations, which are batch preparation or component dosage, premixing, heating of the charge and stirring it in a heated state (homogenization), cooling before pressing.

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Before being mixed with the oil binder, sapropel is dried at 110 °C to remove some of the residual water and subjected to mechanical activation in an AGO-2 planetary mill with a rotational speed of 730 rpm, a drum of 1780 rpm for two minutes to disperse and increase the adsorption capacity. Briquetting is performed on a PC 02.00.000 hydraulic press developed by specialists from the Institute of Oil and Gas Problems, SB RAS, and protected by copyright certificate of the Russian Federation No. 2092309, with priority dated 14.02.94. The test sample is a tablet with a diameter of 25.0 mm and a height of 10.0 mm.

EXPERIMENTAL PART OF THE RESEARCH

The results of research on the determination of optimal compositions and parameters of brown coal briquetting show that tar modification with dried and mechanically activated lake sapropel allows obtaining a binder composition for brown coal briquetting and creating fuel briquettes with high technical characteristics.

The change in moisture content in dry coal affects the cohesive forces between the coal particles. The optimum value of the moisture content of the coal fines is defined by briquetting dried coal with different moisture level under minimum and maximum compacting pressures. The studies conducted to determine the effect of coal moisture on the strength characteristics of briquettes containing coal (8% by weight), tar (15% by weight) are shown in Fig. 1, from which it follows that the value of compacting pressure is closely related to the moisture content of the dried material, and they are in a single-valued relationship. The obtained results show that the compression strength of the samples is maximal at a coal moisture content of 10-11%.

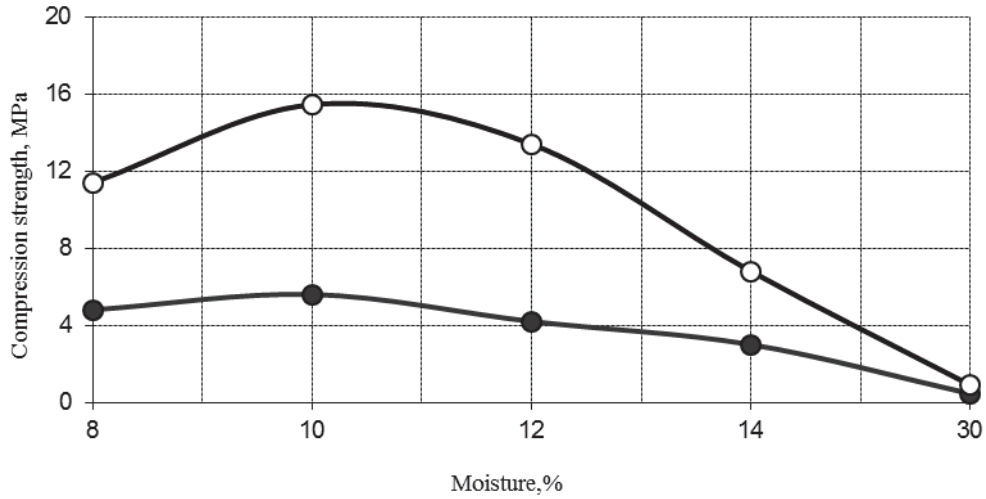

FIGURE 1. The influence of the moisture content of coal on the strength of briquettes obtained at a compacting pressure of 50 MPa (1) and 200 MPa (2)

A significant role in the briquetting process is played by the preparation of the coal charge of the required sieve composition. The sieve analysis of the coal and the distribution of grains of various sizes in the charge must correspond to its maximum compaction, which ensures the highest durability of contacts among the grains and high strength of the briquettes with minimum binder consumption. The investigation of the influence of the granulometric composition of coal on the mechanical properties of briquettes, the results of which are presented in Fig. 2, shows that the increase in compressive strength is particularly noticeable in briquettes containing coal with the smallest size (coal class 0-1.25 mm) and a mixture of coal of different sizes: 0-1.25 (60% by weight), 0-2.5 (30% by weight), 2.5-5 (10% by weight). At the same time, their use for briquetting is irrational due to the introduction of laborious operations of grinding and fractionation into the technological cycle. Therefore, coal with a particle size of less than 2.5 mm is used for further studies. The composition of briquettes is as follows: I – coal (90% by weight) + bitumen (10% by weight); II – coal (85% by weight) + tar (15% by weight). Compacting pressure is 150 MPa.

Compacting pressure, time and processing temperature are varied to determine the operation factors of the technological process by the variation of physical and mechanical properties. The increase in the compacting

pressure to 150 MPa leads to the production of stronger briquettes. When the pressure reaches 200 MPa, the strength of the samples decreases (Fig. 3). The strength characteristics of the briquettes practically meet the requirements of GOST 7299-84 developed for briquettes from brown coals for compressive strength (7 MPa), maximum strength is achieved at 150 MPa. It has been established that the compressive strength of the briquettes increases with the temperature of the final treatment and reaches its maximum value at 230 °C and holding at this temperature for 180 min. The increase of the temperature above 230 °C leads to fire and destruction of the briquettes.

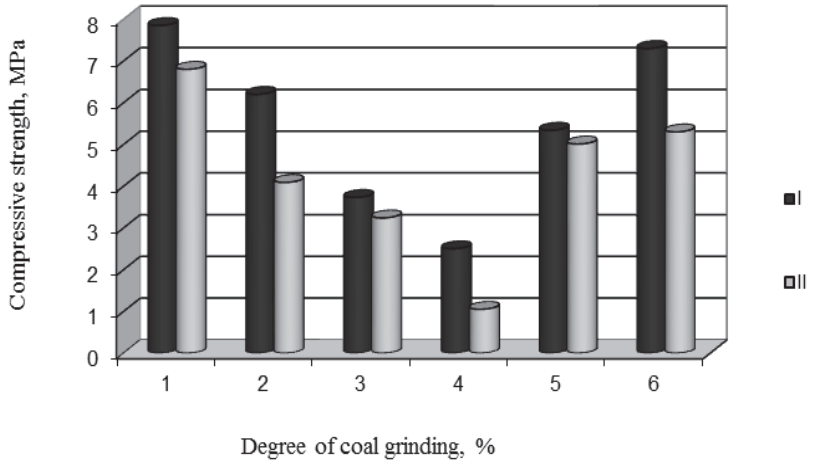

FIGURE 2. The influence of coal size on the strength of briquettes, MPa. Grind size of coal: 1 – 0 to1.25 mm; 2 – 0 to 2.5 mm; 3 – 1.25 to 2.5 mm; 4 – 2.5 to 5.0 mm; 5 – 0 to 1.25 mm (50%), 1.25 to 2.5 mm (50%); 6 – 0 to1.25 mm (60%), 1.25 to 2.5 mm (30%), 2.5 to 5.0 mm (10%)

The increase in the briquette strength with temperature is most likely associated with an increase in the rate of tar oxidation. Binder hardening and the formation of solid high-molecular compounds ensuring a strong bond among the briquette grains result from oxidative polymerization and polycondensation of the binder. It is assumed that, in addition to its sorption properties, sapropel also demonstrates catalytic properties. Most likely, the organic component and the structure of the sapropel itself catalyzes the oxidation of heavy oils and tar resins to a bitumen state.

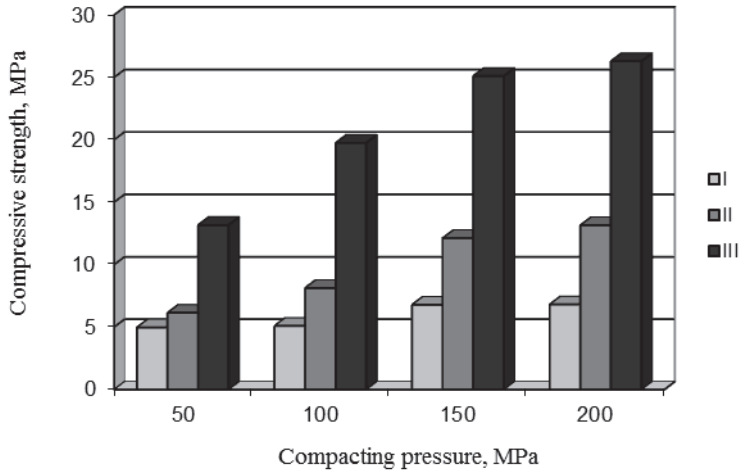

FIGURE 3. Briquette strength as dependent on compacting pressure, MPa. Composition: I – coal (85% by weight) + tar (15% by weight); II – coal (75 wt%) + tar (15 wt%) + sapropel (10 wt%); III – coal (75% by weight) + tar (15% by weight) + act. sapropel (10% by weight)

Investigation of physical and mechanical characteristics has shown that, in order to obtain samples that meet the requirements of standardized GOST, it is necessary to accomplish the briquetting process in accordance with the established technological regulations. The obtained results indicate that the following parameters for obtaining high-quality fuel briquettes are optimal: coal size of 0-2.5 mm, analytical coal moisture of 10-11%, compacting pressure of 150.0 MPa, processing temperature of 230 °C, and thermal treatment time of 180 min.

CONCLUSION

Thus, the present research illustrates technological methods for briquetting brown coal using modified binder composition based on oil residue and rational regimes of its operation, which allow obtaining strong briquettes for transportation over long distances. During combustion, the briquettes do not stick together, they do not form slag deposits and produce only ash. Compared to ordinary coal burning, the efficiency of the combustion devices increases by 25-35%, they burn 1.5 to 2 times as long, the emission of solids with flue gases is more than halved, and the underexposure of combustible components decreases by 15-20%. The briquettes are not toxic and economical in use; due to their compactness, they are convenient in storage and represent an ecologically safe type of fuel.

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