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THE IMPORTANCE OF USING ORGANIC BINDERS IN OBTAINING BRICKETS

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Abstract

This work examines organic binders—specifically coal tars modified with mechanically activated organo-mineral additives—for producing durable fuel briquettes from low-grade brown-coal waste. The binder systems were prepared by mechanically activating mineral components (e.g., ash/slag fines, clayey fractions) and blending them with tar to enhance adhesion, plasticity, and curing. Brown-coal powders from mountain deposits were briquetted under moderate pressure and ambient curing. Performance was assessed by cold compressive strength, drop resistance, abrasion loss, water uptake, ash content, and lower heating value. The modified organic binders yielded briquettes with improved mechanical integrity and moisture resistance compared with tar-only controls, while maintaining acceptable combustion characteristics. Mechanical activation of the organo-mineral fraction reduced binder dosage needed for target strengths, enabling higher coal content and better energy density. Overall, organic binders reinforced with activated mineral phases offer a practical, lower-cost route to valorize brown-coal waste into transportable, storable, and efficiently combustible briquettes.

Keywords: Brown coal; coal tar binder; organo-mineral additive; mechanical activation; fuel briquette; ash content; heating value; moisture resistance; compressive strength.

Introduction

One of the main sectors of the republic's economy is the coal industry. Despite the development of new types of heat sources, coal remains one of the main natural resources used as fuel for both domestic and industrial needs.

In terms of coal production, the Angren coal mine occupies a leading position in our republic, 85% of the coal mined in our republic belongs to the Angren coal mine, and the remaining 15% to the Boysun and Shargun coal mines [1].

Today, a number of new projects are being implemented to create new deposits and modernize production. The emergence of new large companies is of great importance for the modern development of coal mining in the republic.

The Angren coal mine is the largest in Uzbekistan. In addition, all conditions have been created for the transportation of coal products. This co

Currently, the manufactured briquettes do not fully meet the consumer price and technical requirements for use in cold weather. Angren coal is characterized by a low content of humic acids, resins, and substances used for the good binding of coal particles, which is one of the main reasons for the technological complexity of their briquetting [2.3].

One of the rational ways to efficiently use and store coal is to briquette coal powder, which solves the problem of converting low-grade fuel unsuitable for transportation, long-term storage, and combustion into briquetted fuel. The expediency of briquetting brown coal powder lies in the fact that it prevents the high demand for affordable fuel for household needs, as well as the accumulation of millions of tons of energy-rich coal powder occupying large areas in coal mines.

Waste from industrial enterprises, natural and household waste were selected as a binder that further improves the quality and heat level of fuel. Its use will be economically beneficial due to its affordability and availability. To improve briquette quality, it is most effective to use modification with structural active additives, which are used as natural sorbents [4.5].

In the technology of brown coal briquetting, binders are adopted as a variable factor, which is a necessary condition for the binding of dispersed substances using organic and mineral substances, along with a wide raw material base and low cost, an increase in their specific surface area, surface area, porosity, as well as high adsorption properties are achieved.

The general technological scheme for obtaining brown coal briquettes consists of several operations: preparation of the charge, pressing, heat treatment, and cooling. To achieve high efficiency, before adding a binder, the moisture content in the powder is dried at 90°C and ground in mills. In the process of mechanical activation, with an increase in dispersion and the specific surface area of the particles, they transition to a highly dispersed state, which is characterized by increasing values of surface energy, the order of crystal structure is disrupted, defects appear, and a transition to a metastable, unbalanced state of the particles occurs [6].

The study of the textural properties of fillers shows that in the activated state, the filler substances are characterized by a smaller particle size, a specific geometric surface area, and an increase in pores, which can be determined by an increase in pore volume compared to fillers in the non-activated state [7.8].

Table 1. Basic physicochemical properties of tar

Indicators	Gudron				
Addition With Addition SP Aktiv with Addition. SP With Addition. BU Aktiv with the suffix BU	Without	Addition	With Addition	SP Aktiv with Addition.	Aktiv with the suffix BU
density at 20 °C, kg/m3	955,10	930,10	924,52	953,68	942,54
conditional viscosity at 80°	22,95	16,07	14,01	16,98	15,87
Mass fraction of silica gel resins, %	17,81	18,94	19,95	17,98	18,76
Mass fraction of asphaltenes, %	5,76	6,94	8,01	8,98	7,99
Oils, %	74,85	72,55	70,97	73,98	72,85
Mass fraction of paraffin, %	8,50	9,01	9,02	6,99	6,87
Coking, %	11,01	13,99	15,03	12,30	12,98
Temperature of softening not lower than °C	55	53	51	50	49
Needle penetration depth at 25 °C, 0.1 mm	270	203	185	207	195

Data on the assessment of the influence of fillers on the main physicochemical properties and the chemical composition of the binder material in the group are presented in Table 1. It shows a significant influence on the rheological indicators of the fillers, as well as the composition of the binder on the group composition [9].

Comparison of the presented data shows that the introduction of activated fillers allows maintaining the technological parameters of the resin and significantly improving them in some respects. Due to high porosity, fillers have a higher sorption capacity compared to resin oils. Immobilization of oils helps to reduce the mobile dispersion medium, which, apparently, reduces the softening point and resin penetration [10.11].

It was found that after modification in the resin, the amount of fats decreases by 1.2-9.5%, viscosity by 20-41%, but the amount of resins increases by 1.76-22.82%, oxygen by 2.5-4.6 times [12].

Asphaltenes are one of the main carriers of the sintering and rheological properties of binders obtained from oil. The content of asphaltenes in the resin with additives ranged from 6.98 to 9.75%, and with activated additives - from 7.12 to 9.97%.

The introduction of fillers leads to a decrease in this indicator to 170-200 units, and with activated fillers - to 160-190 units. The change in resin penetration filled with sapropel is similar to the penetration of resin with coal and zeolite fillers. The coking value of the binder without additives is 12.54%, with additives - 12.05-15.12%, with activated additives - 13.12-16.01%.

Analysis of the change in the properties of the binder composition shows that preliminary activation in the mill for any binder leads to an improvement in the physical and mechanical properties compared to the binder containing an unactivated filler of the same concentration [13].

Preliminary results show that the following parameters are optimal for obtaining high-quality fuel briquettes: coal volume 0-2.5 mm; analytical moisture content of coal - 10-11%; processing temperature - 230°C; heat treatment time - 180 min.

One of the requirements for brown coal briquettes is to maintain sufficient capacity for transporting the material over long distances. Data obtained from physico-mechanical studies of compositions of various compositions indicate an increase in strength indicators when using a composition consisting of 15% resin, 10% filler, and 75% coal, which is associated with good bonding. Interactions in the "coal-binder" interface are associated with an increase in the content of asphaltenes and resins and a decrease in the content of low-polarity oils in the binder [14].

The introduction of an activated filler as a structural active additive into the binder leads to a significant change in the compressive strength of the samples compared to samples with an untreated filler.

It was established that the optimal time for activating sapropel and brown coal in the mill is 2 minutes, which allows achieving the best strength value of the briquettes. Compared to briquettes containing a non-activated filler of the same concentration, the power increases by 1.5-2.0 times [15].

The results of the study of the set of physical and mechanical tests of brown coal briquettes, presented in Table 1, show that the introduction of activated structural-active fillers (sapropel, brown coal) into the resin leads to a significant improvement in technical characteristics. As can be seen from the developed briquettes, the greatest contribution to increasing the strength

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of briquettes is made by activating the filler. Thus, the value of the pressure force is 1.5-2 times higher than the normalized value, with the activation of additives - by 1.8-3.2 times, depending on the filler characteristics, and by 1.7-4.0 times higher compared to samples containing the original resin.

Ash content is in the range of 14.20-18.50%, which is significantly lower than the normal value; a slight increase in ash content is observed in briquettes containing zeolites and zeolites due to the high mineral content. The sulfur content in the obtained briquettes is 8-19 times lower. The moisture content in the samples containing the binder is approximately 1.5 times lower than in the original coal, which is associated with the introduction of the additive and a slight drying during the preparation of the mixture (thermal treatment). The water absorption of the briquettes is 2.15-2.45%, which is 18-28% lower than the standard values, and the residual strength of the briquettes decreases by 15-25%. Also, all samples are characterized by non-adhesion to each other. With the introduction of fillers into the resins, the caloric value of the briquettes increases to 29.89 MJ/kg [16.17].

According to the composition of volatile substances, briquettes obtained with optimized technological parameters and compositions belong to the category of smoky household solid fuels. However, with an increase in exposure time at a processing temperature from 230°C to 360 minutes, the volatile content can be reduced by 14-16%. To remove volatile substances introduced with binders and reduce "smoke content," the briquettes are subjected to secondary heat treatment. The combustion of the obtained fuel at a temperature of 850°C showed that the combustion of the briquettes occurs within 110-113 seconds, and for briquette samples containing unconverted resin, a slight burning is observed during combustion. The remaining indicators meet the established requirements.

To determine the influence of the composition and technological methods of brown coal briquettes on the processes of structure formation and, accordingly, on the nature of changes in the properties of the compositions, structural studies were conducted using X-ray diffraction.

Table 3.

Sostav kompozitsii, ob. %			*T*, °C obr	2θ°	*d*, A°	α, %
ugol	gudron	–	25	26,68	3,348	40,3
			230	26,62	3,348	42,6
ugol	gudron	seolit	25	26,67	3,342	34,4
			230	26,59	3,352	48,3
ugol	gudron	akt. seolit	25	26,70	3,339	39,2
			230	26,59	3,352	53,7
ugol	gudron	sapropel	25	26,61	3,352	32,5
			230	26,70	3,339	37,4
ugol	gudron	akt. sapropel	25	26,66	3,344	36,5
			230	26,59	3,360	38,8
ugol	gudron	ugol	25	26,68	3,341	36,0
			230	26,61	3,350	46,2
ugol	gudron	akt. ugol	25	26,64	3,346	41,8
			230	26,50	3,363	43,0

As can be seen from Table 3, the crystal peaks of all samples are in the range of 26°, and the interplanar distances of the crystal lattice practically do not change. Comparison of them with the diffraction curve of the original resin-based briquette shows a slight shift of the amorphous brittle maximum in briquettes with activated additives to smaller diffraction angles [18].

It was established that heat treatment of all briquette samples leads to an increase in the degree of crystallinity, and based on the obtained results, the intensity of the crystal peak also depends on the nature of the filler in the binder. Replacing the binder with activated fillers leads to a slight increase in the degree of crystallinity. The nature of the change in a from the filler composition indicates a complex nature of the filler's influence on the crystallization processes of the resulting polymer substance.

The decrease in α with the introduction of sapropel into the binder composition is probably associated with a decrease in the proportion of crystalline regions due to the agglomeration of filler particles and a decrease in the polymer crystallization rate. Thus, when resin is modified with organomineral fillers, their effect mainly extends to amorphous zones [19].

To determine the permissible shelf life of briquette samples, reduce mechanical strength, and take into account possible damage to the briquette surface during aging, full-scale tests were conducted under the influence of climatic factors for 6 months. Every 2 months, the loss of pressure force, water absorption were assessed, and visual examination of the samples was carried out.

As a result of the research, fuel briquettes with an improved set of technical characteristics were obtained. To ensure the required technical quality of briquettes, provided for by regulatory and technical documentation, a technology for resin transformation using mechanical activation methods has been developed, which contributes to an additional increase in pressure strength and the preservation of mechanical properties for a long time.

The results of the conducted research work can be implemented for conducting pilot tests and organizing the production of brown briquettes from fine coal particles based on open-pit brown coal deposits [20.21].

Potential clients and consumers of briquetted coal can be industrial enterprises located in the territory of our republic, enterprises under the jurisdiction of the Ministry of Housing and Communal Services and Energy, and energy companies. In addition, it is possible to use social facilities, private individuals who consume coal for household purposes (heating houses, cottages, baths, saunas, small farms, fireplaces, boxes, garages, etc.).

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