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Thermal Capacity of Enriched Fuel Briquets Produced from the Fine of Ekibastuz Coal

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Abstract. The object of the research work was coal fines and processes of enrichment of Ekibastuz coal to produce fuel briquettes with increased calorific value and less ash content. Research, scientific substantiation of technology for obtaining high-calorific coal briquettes from fines of Ekibastuz coal, using various binders and the possibility of further coking, designing and manufacturing equipment for the implementation of technology, was made. The standard methods of theoretical and experimental research widely used in metallurgy, machine building, computer systems, etc. were used in the work. The characteristics of briquettes on bio-binding and on petroleum pitch with enrichers in the form of rubber-technical soot and anode dust of electrolysis cell for aluminum production have been established. It is revealed that the calorific value of briquettes is higher than that of Ekibastuz coal (Pavlodar region) by 20-40%, and the heating value is the highest for briquettes with an enrichment agent in the form of anode dust and a binder in the form of petroleum pitch (-NH combustion = 6840.8 kcal / kg). Briquettes on petroleum pitch with an enrichment agent in the form of anodic dust of aluminum electrolysis can be used as industrial briquettes for further use in metallurgy.

Introduction

The Republic of Kazakhstan ranks 8th in the world in terms of coal reserves. In Kazakhstan, out of the 155 known coal deposits, more than 40 were studied with industrial reserves of about 35.8 billion tons (3.6% of the world's reserves). The largest of them are Ekibastuz (12.5 billion tons), Karaganda (9.3 billion tons) and Turgai (5.8 billion tons) coal basins.

The Ekibastuz coal basin is being developed in an open way, which in turn negatively affects the ecological situation in the region. Pollutants and dumps after them are polluting factors. One of the heaviest polluting factors is the drift of coal dust and fines from open coal mines and dumps. This causes irreparable harm to lands suitable for agriculture [1-3].

One of the problems of briquetting at the moment is the impossibility of obtaining briquettes without adding non-flammable binders, which, in turn, will again raise the already high ash content of briquettes. In this project, as know-how, it is considered the possibility of obtaining in the role of a binder the processed organic products of the livelihood of cattle or some by-products of distillation of oil that are combustible substances and will not reduce the percentage of the heating part of the briquette [4,5].

These developments are of significant importance for the practice of coal enrichment and the processing of substandard fines. For the first time on the basis of experimental data, a method for obtaining fuel briquettes using substandard fines of Ekibastuz coal and adding know-how of materials was proposed. Design work on designing a briquetting press and a screw mixer with a heater has been completed. When implementing part of the Project, the commonly used methods of theoretical and experimental research are widely used in metallurgy, machine building, modern methods of designing machines and mechanisms using computer systems of design and engineering analysis, etc. [6,7].

One of the most effective methods for solving this problem is the use of accumulated coal dust and fines for the production of coal briquettes. The essence of the idea is to produce briquettes from coal fines and dust of high ash coals from the Ekibastuz deposit with the possibility of subsequent coking by increasing the carbon content in it, that is, the heating part. For these purposes, it is planned to use the technology of obtaining carbon soot, developed at the moment, by processing rubber waste and anodic dust of aluminum electrolysis. Preliminary experiments clearly showed the suitability of these materials for the enrichment of fuel and industrial briquettes. Thus, the problem of recycling of these wastes is being handled in passing [8-12].

Field Study and Results

The object of the study was coal fines and processes of enrichment of Ekibastuz coal with the production of fuel briquettes with increased calorific value and less ash content, contributing to the improvement of the environmental situation in the coal-mining and coal-processing regions.

In the experiments briquette mixtures with different compositions and granulometric sizes of coal fines are prepared, the size of the anode dust and rubber technical carbon black are constant.

From each mixture of a certain composition, five samples were prepared and their average value gave the sample composition. Thus, six samples are presented. One batch of such samples was taken to LLP "Institute of Coal and Technology Chemistry" (Astana), as independent experts, to determine the carbon and the enthalpy of combustion of coal briquettes. The characteristics of the samples are given in Table 1.

Table 1. Characteristics of fuel briquettes.

Name of components	Content, [%]	Fraction, [mm]	Mixing time, [min]	Heating time, [min]	Heating temperature, [°C]	Density of the briquette, [g/sm^3]	Density of the briquette, [MPa]
Coal Anodic dust Pitch oil	5 30 5	0.8-1.2 0.2-0.4 0.2-0.4	8	5	200	1.41	25.5
Coal Rubber soot Peck oil	3 27 20	0.8-1.0 0.0006-0.001 0.2-0.4	5	5	250	1.44	25.5
Coal Dust anodic Peck oil	5 25 30	1.0-1.2 0.2-0.4 0.2-0.4	8	5	200	1.42	25.5
Coal Dust anodic Peck oil	3 27 20	1.0-1.2 0.2-0.4 0.2-0.4	5	5	250	1.46	25.5
Coal Dust anodic Peck oil	45 30 25	0.8-1.0 0.2-0.4 0.2-0.4	8	5	250	1.45	25.5
Coal Rubber soot Biomass slurry with water	0 25 25	 0.8-1.2 0.0006-0.001	5	dry 60 min.	105	1.38	25.5

The briquette mass was mixed in a roller mixer in the powder state of the three components, then strictly weighted on a precise weight of 140 g, the mass of the mixture was placed in a laboratory sleeve, 50 mm in diameter and 120 mm high with a pallet and heated in a thermal furnace for 5 minutes at a temperature of 200-250 °C. After that, the sleeve with the mixture was placed under a six-ton press and compacted at a specific pressure of 25.5 MPa. Then, the sample of the briquette was pushed out of the sleeve and the density of the resulting briquette was determined. The received briquettes height varied within 50 + 1 mm, because of the instability of the pneumatic pressing unit, which is characteristic of such machines working on compressed air. Therefore, the density of the briquettes obtained fluctuated within the permissible limits about 1.38 to 1.46 g / sm^3 [4 ± 6]. The specific pressing pressure of the mixture in a sleeve 50 mm in diameter was calculated by Eq.1:

$$P_{spec} = P_{pr} / F_b \text{ MPa} \quad (1)$$

where P_{pr} is press force, kgf; F_b is the cross-sectional area of the briquette, sm^2.

According to the certificate, issued by LLP Institute of Chemistry of Coal and Technology (Astana), the best indicators are samples No. 1, No. 3, No. 5, i.e. sample, where the composition corresponds to the analytically calculated briquette mass formula and the duration of dry mixing (Table 2).

Table 2. Results of chemical analysis for carbon (C) in coal briquettes and calculating the enthalpy of combustion of coal briquettes.

№ of briquettes	Carbon content, [%]	$-\Delta H^0_{burning}$,[kJ/kg]	$\Delta H^0_{burning}$,[kcal/kg]
1	61.05	23834	5696.5
2	54.63	19523	4666.1
3	63.89	25741	6152.3
4	60.74	23626	5646.0
5	68.18	28622	6840.8
6	56.31	20651	493.7

Calculation of combustion was carried out according to the formula from the experimental data on the enthalpy of coal combustion in the Northern section of the Ekibastuz basin (by Eq.2)

$$\Delta H_{burn.} = 17161 - 671{,}5\ (\%\ C),\ \text{kJ/kg}. \quad (2)$$

Comparison with the heat of combustion of Ekibastuz coal (17380 kJ / kg) shows higher thermal characteristics of coal briquettes both on bio-binding and on petroleum pitch.

The proportion of the composition was determined experimentally. So to determine the optimal composition of coal-soot mixture, a series of experiments was carried out. Each experiment was conducted three times for the reliability of the results. In these experiments, water functioned temporarily to form a mixture in the form of a briquette, to increase the reliability of the effect of soot on reducing the ash content of the briquette mass. This is done to ensure that the change in ash content occurs only due to the amount of soot without the influence of the binder in the form of biomass.

Also, for different sizes of coal fractions, graphs were constructed for the dependence of the ash yield on the coal content in the briquette, and regression equations, determination coefficients (Figures 1, 2) were obtained. To test the adequacy of the model, the Fisher criterion was calculated. The construction of graphs and the calculation of the regression equations, correlation coefficients and the Fisher criterion were carried out using the Microsoft Office Excel software package.

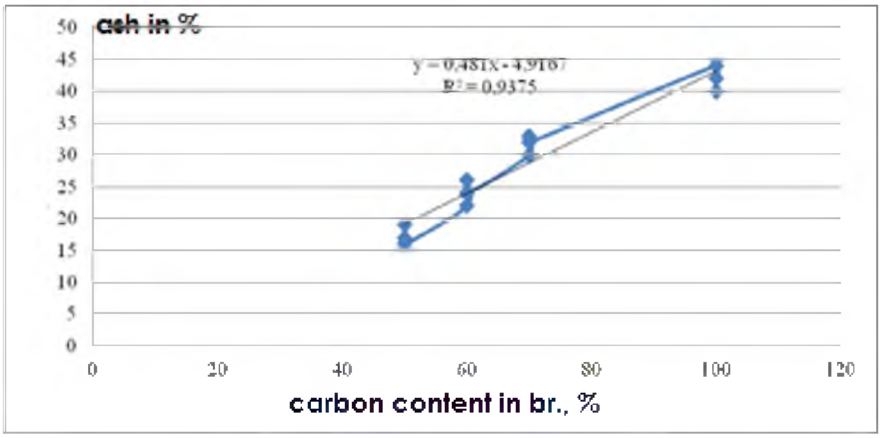

Fig. 1. Dependence at a coal fraction size of 1 mm (Fisher's criterion F = 0.007).

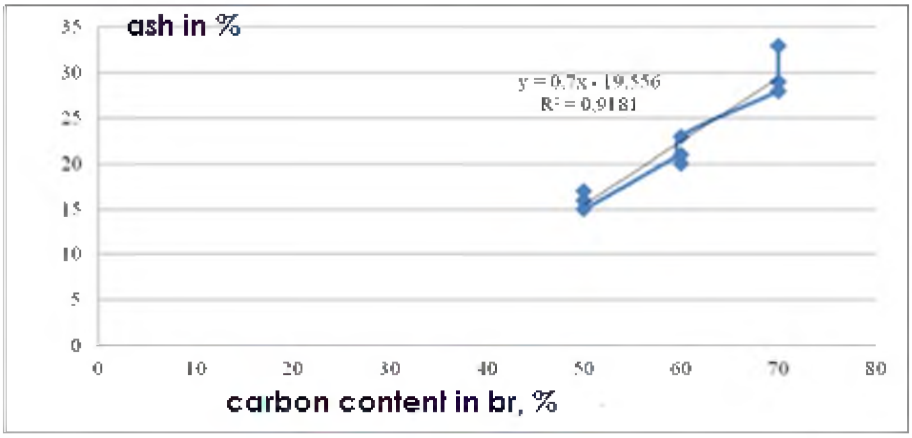

Fig. 2. Dependence for the size of the 0.8 mm fraction (Fisher's criterion F = 0.015).

From each mixture of a certain composition, five samples were prepared and their average value gave the sample composition. Thus, six samples are presented. One batch of such samples was taken to LLP "Institute of Coal and Technology Chemistry" (Astana), as independent experts, to determine the carbon and the enthalpy of combustion of coal briquettes.

During the reporting period, the following results were obtained. The characteristics of briquettes on bio-binding and on petroleum pitch have been established. It is revealed that the calorific value of briquettes is higher than that of Ekibastuz coal by 20 - 40%, and the heating value is the highest for briquettes with an enriching agent in the form of anodic dust of aluminum electrolysis electrodes and a binder in the form of oil pitch (-NH combustion = 6840.8 kcal / kg) [13-16].

The technology of manufacturing briquettes on bio-binding and petroleum pitch has been developed [17, 18].

A promising line of further research has been identified, namely, the need for studies on the assessment of the possibility of using industrial briquettes for coking and use in metallurgy, the manufacture of laboratory and research equipment for the further commercialization of the project.

The quantitative ratio of the components in the briquette is determined. The density of the components and the necessary density of the briquette were determined, the weight ratios of the components and the mass of the charge loaded into the batch were calculated [19, 20].

Conclusions

In the experimental part, a method for increasing the carbon content in the Ekibastuz coal was considered. by mixing coal fines with soot. In the course of the study and analysis of Ekibastuz coal, we found that in the main volume of coal produced, about 17% is coal fines with a fraction of the order of 0-3.0 mm. This allows you to get fuel and coke briquettes with minimal costs for preparation.

Soot was used in the rubber, high-quality carbon content in which reaches 96-98%. To produce this carbon soot, a new installation for collecting soot from rubber products was developed and assembled. As a result of the experiments, it was found that when burning 1 kg of tires, an average of 24 grams is allocated. soot. As a result of mixing coal fines and soot, we reduced ash output from fuel from 34-57% to 15-17%.

The composition of the mixture with a 40% carbon content, 40% carbon soot, 20% biomass with a 0.8 mm fraction size of coal, can be taken as the main one, since with these values a minimum amount of ash is equal to 15%.

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