



THERMAL CAPACITY OF ENRICHED FUEL BRIQUETS PRODUCED FROM THE FINE OF EKIBASTUS COAL

Ye.S. Abdrakhmanov¹, A.V. Bogomolov², P.O. Bykov², A.B. Kuandikov²

^{1,2} Metallurgy Department, Pavlodar, Kazakhstan

Abstract:

The object of research or development: 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.

Objective: 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.

Method or methodology of the work: The standard methods of theoretical and experimental research widely used in metallurgy, machine building, computer systems, etc. were used in the work.

The results of the work and their novelty: The characteristics of briquettes on bio-binding and on petroleum pitch with enrichers in the form of rubber-technical soot and anode dust of electrolyzers 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). The structures of the soot separator, sorting and sifting equipment, mixing laboratory equipment, the mouthend briquetting press, the briquetting press and the screw mixer with the heater have been designed. Based on the results of the research, the project manager and co-authors published 15 scientific publications, patents and theses of international conferences.

Application area: Briquettes for bio-binding can be used as fuel for combustion in centralized village boiler houses, private houses and farms. 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.

Forecasting assumptions about the development of the object of research: Further studies are required to assess the feasibility of using industrial briquettes for coking and use in metallurgy, the manufacture of laboratory and research equipment to further commercialize the project.

Keywords: Wastes; Thermal Power Engineering; Coal; Briquettes; Soot.

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1. 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].

Assessment of the current state of the scientific problem being solved: Economical and rational use of raw materials, stimulating the growth of industrial production, is one of the main requirements put forward by the Government of the Republic of Kazakhstan in the field of further development of manufacturing industries. In the State program of industrial-innovative development for 2015-2019, one of the priority sectors of the economy is the production of machinery and equipment for the mining industry [1, 2].

In the coal industry, briquetting is the promising technological process for agglomeration of coal fines, where the main types of equipment are presses of various designs.

The basis and initial data for the development of the topic: 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 the lands suitable for agriculture.

Justification of the need for research: 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.

Scientific and technical level of development: 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.

Metrological provision of research: 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.

Relevance of the topic: 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 obtain 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.

Novelty of the theme:

- characteristics of briquettes on bio-binding and petroleum pitch have been established;
- 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 enrichment agent in the form of anodic dust of aluminum electrolysis electrodes and with a binder in the form of oil pitch (-NH combustion = 6840.8 kcal / kg);
- The technology of manufacturing briquettes on bio-binding and petroleum pitch has been developed;
- The design of the soot separator, sorting and screening equipment, a mixing laboratory plant, a mouth-briquetting press, a roller briquetting press and a screw mixer with a heater has been developed.
- Relationship with other research projects. This research corresponds to the direction - "Complex use of mineral raw materials, waste processing, environmental safety and development of regional energy."

The purpose of research and the place in the implementation of research in general:

- Research, scientific substantiation of technology for obtaining high-calorific coal briquettes from fines of Ekibastuz coal using bio-binding and oil pitch, designing and manufacturing equipment for technology implementation.

The tasks of research and the place in the implementation of research in general:

- 1) Investigation of adhesion-cohesive properties of binding materials (bio-binding and oil pitch).
- 2) Research, development of technology for manufacturing briquettes on bio-binding and petroleum pitch. Comparative analysis of briquettes.
- 3) Design of laboratory equipment.

Approbation of practical results: The results of the work are presented in 15 scientific publications, patents and proceedings of international conferences [3 - 18]. The results of the work were reported and discussed at international scientific conferences Pavlodar, "Processing of industrial wastes as a pledge of ecological safety" - Pavlodar: 2016, held in the international investment forum "ERTYS INVEST 2016", international conferences (Great Britain, Czech Republic, Bulgaria), two applications for the patent of the Republic of Kazakhstan were filed, two earlier submitted patent applications were formalized, one patent was received (Annex A), a memorandum of cooperation was concluded Institute of Chemistry of Coal and Technology "(Astana) for further commercialization of the project (Appendix B).

2. Materials and Methods

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. During the experiments, the following equipment, devices, instruments and materials were used:

- standard laboratory sleeve (Usman Mechanical Plant);
- detachable laboratory sleeve;
- six-ton pneumatic press of model 91271B;
- compressor type G-12;
- electric furnace muffle model SNOL-6,7 / 1300;
- electric oven drying model SNOL-6,7 / 350;
- Press WIM WDW-200;
- microscope model METAM LV-34;
- electronic scales with an accuracy of 0.01 grams;
- laboratory threaded mixer;
- Coal fines of fraction 0.8 - 1.2 mm, rubber soot with a constant fraction of 60-100 Å, anode dust of electrolyzers to produce an aluminum fraction of 0.2-0.4 mm.

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. 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 / sm³ [4 ± 6].

The specific pressing pressure of the mixture in a sleeve 50 mm in diameter was calculated by formula

$$P_{\text{spec}} = P_{\text{pr}} / F_{\text{b}}, \text{ MPa}$$

Where, P_{pr} - press force, kgf;

F_b is the cross-sectional area of the briquette, sm^2 .

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.

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 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

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

N ^o of briquettes	Carbon content, %	$-\Delta H^0_{\text{burning}}$, kJ/kg	$-\Delta H^0_{\text{burning}}$, kkal/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:

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

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.

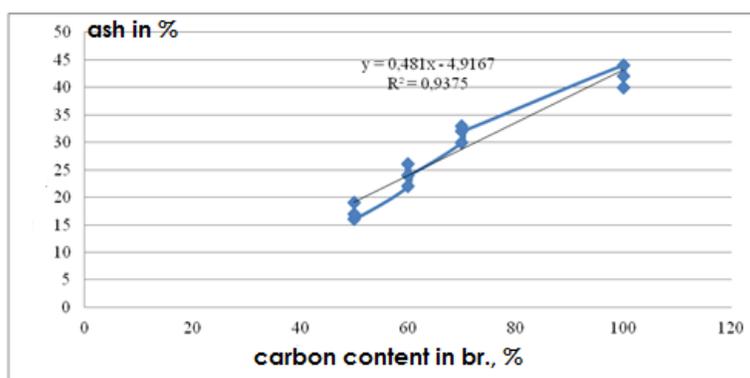


Figure 1: Dependence at a coal fraction size of 1 mm (Fisher's criterion F = 0.007)

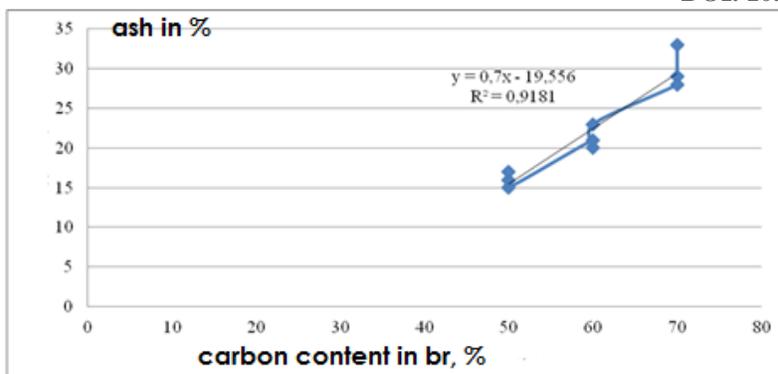


Figure 2: Dependence for the size of the 0.8 mm fraction (Fisher's criterion $F = 0.015$)

Thus, the dependence of the ash yield on the content of carbon soot in the briquettes at the size of the fraction 0.8 mm (Fisher's criterion $F = 0.72$) can unambiguously conclude that the composition of the mixture: coal - 50%, soot - 50%, with the sizes of coal fractions and soot of 0.8 mm, can be taken as the main one, since at these values the minimum amount of ash is equal to 15%.

3. Results and Discussions

3.1. Composition of the Briquette

To obtain fuel and industrial briquettes from enriched Ekibastuz coal, it is necessary to determine the constant parameters of briquettes, such as geometric dimensions, wet and dry strength and density at constant values of constituent components.

The components of the briquette are: a coarse brown coal coarse size 0.8 - 1.2 mm powdered enrichment agent and a binder material with a particle size of 0.2-0.4 mm.

3.2. Experimental Part

During the experiments, the following equipment, devices, instruments and materials were used:

- standard laboratory sieve (Usman Mechanical Plant);
- detachable laboratory sieve;
- six-ton pneumatic press of model 91271B;
- compressor type G-12;
- electric furnace muffle model SNOL-6,7 / 1300;
- electric oven drying model SNOL-6,7 / 350;
- Press WIM WDW-200;
- microscope model METAM LV-34;
- electronic scales with an accuracy of 0.01 grams;
- laboratory threaded mixer;
- Coal fines of fraction 0.8 - 1.2 mm, rubber soot with a constant fraction of 60-100 Å, anode dust of electrolyzers for producing aluminum of fraction 0.2-0.4 mm.

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

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 / cm³.

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 test results are given in Appendix B.

Sample No. 1. Mass of the mixture $m_b = 140$ g; diameter of the sleeve $d_b = 50$ mm = 5 cm; height of the obtained briquette $h_b = 50.7$ mm = 5.07 cm; $\rho_b = 1.41$ g / cm³. Composition of components: 45% - Ekibastuz coal fines fraction 0,8 ÷ 1,0 mm; 30% - anodic fraction dust 0.2 - 0.4 mm (constant); 25% - pitch of oil fraction 0.2 - 0.4 mm (constant). The mixing time in the roller mixer is $\tau = 8$ minutes. The time of heating the mass in the sleeve in the thermo-furnace is $t = 200$ °C, $P_{spec} = 25.5$ MPa.

The specific pressing pressure of the mixture in a sleeve with a diameter of 50 mm was calculated from formula (2.1)

$$P_{spec} = P_{pr} / F_b, \text{ MPa} \quad (2.1)$$

Where, P_{pr} - press force, kgf;

F_b is the cross-sectional area of the briquette, sm².

Sample No. 2. Mass of the mixture $m_b = 140$ g; diameter of the sleeve $d_b = 50$ mm = 5 cm; height of the obtained briquette $h_b = 49.5$ mm = 4.95 cm; $\rho_b = 1.44$ g / cm³. Composition of components: 53% - Ekibastuz coal fines fraction 0,8 ÷ 1,0 mm; 27% - carbon soot with a rubber fraction of 60 - 100 Å; 20% - pitch of oil fraction 0.2 - 0.4 mm (constant). The mixing time in the roller mixer is $\tau = 5$ minutes. The time of heating the mass in the sleeve in the thermo-furnace is $t = 250$ °C, $P_d = 25.5$ MPa.

Sample No. 3. Mass of the mixture $m_b = 140$ g; diameter of the sleeve $d_b = 50$ mm = 5 cm; height of the obtained briquette $h_b = 50.2$ mm = 5.02 cm; $\rho_b = 1.42$ g / cm³. Composition of components: 45% - Ekibastuz coal fines fraction 1.0 ÷ 1.2 mm; 25% - anodic fraction dust 0.2 -

0.4 mm (constant); 30% - pitch of oil fraction 0,2 - 0,4 mm (constant). The mixing time in the roller mixer is $\tau = 8$ minutes. The time of heating the mass in the sleeve in the thermo-furnace is $t = 200$ °C, $P_{sp} = 25.5$ MPa.

Sample No. 4. Mass of the mixture $m_b = 140$ g; diameter of the sleeve $d_b = 50$ mm = 5 cm; height of the obtained briquettes $h_b = 49$ mm = 4.9 cm; $\rho_b = 1.46$ g / cm³. Composition of components: 53% - Ekibastuz coal fines fraction 1.0 ÷ 1.2 mm; 27% - anodic fraction dust 0.2 - 0.4 mm (constant); 20% - pitch of oil fraction 0.2 - 0.4 mm (constant). The mixing time in the roller mixer is $\tau = 5$ minutes. The time of heating the mass in the sleeve in the thermo-furnace is $t = 250$ °C, $P_d = 25.5$ MPa.

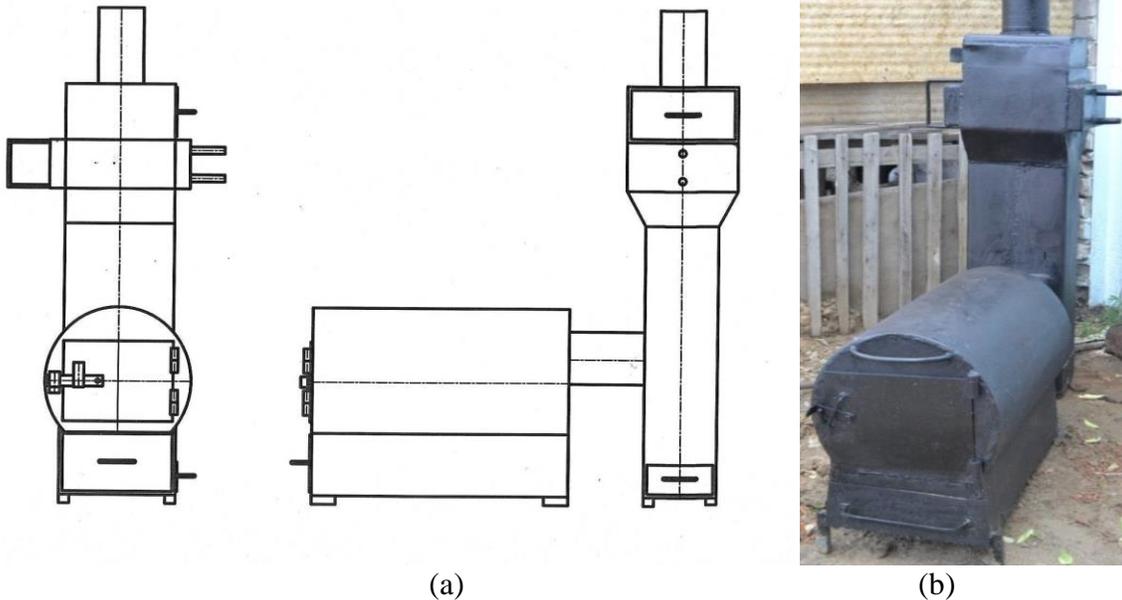
Sample No. 5. Mass of the mixture $m_b = 140$ g; diameter of the sleeve $d_b = 50$ mm = 5 cm; height of the obtained briquette $h_b = 49.3$ mm = 4.93 cm; $\rho_b = 1.45$ g / cm³. Composition of components: 45% - Ekibastuz coal fines fraction 0,8 ÷ 1,0 mm; 30% - anodic fraction dust 0.2 - 0.4 mm (constant); 25% - pitch of oil fraction 0.2 - 0.4 mm (constant). The mixing time in the roller mixer is $\tau = 8$ minutes. The time of heating the mass in the sleeve in the thermo-furnace is $t = 250$ °C (with an exposure in the oven for 5 minutes), $P_d = 25.5$ MPa.

Sample No. 6. Mass of the mixture $m_b = 140$ g; diameter of the sleeve $d_b = 50$ mm = 5 cm; height of the obtained briquette $h_b = 47.3$ mm = 4.73 cm; the mass of the raw briquette is 128.3 g. Composition of the components: 50% - Ekibastuz coal fines fraction 1.0 ÷ 1.2 mm; 25% - carbon soot with rubber fraction 60 - 100 Å; 25% - a suspension of biomass with water. The mixing time in the roller mixer is $\tau = 5$ minutes. The time of heating the mass in the sleeve in the thermo-furnace is $t = 105$ °C, the drying time is 60 minutes, $P_d = 25.5$ MPa.

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.

3.3. Precipitation Laboratory Installation

The design of the soot trap laboratory is shown in Figure 3. It is a horizontal cylindrical furnace and a chimney with a bunker for collecting soot. In the chimney there is a filtration and trapping system for soot, which consists of three rows of water cooling pipes and a filter cassette of three rows of metal nets. The size of the cells of the metal grid is 1 × 1 mm. Rubber-technical waste, put in the furnace through the door to the grate. As a result of burning, the soot is carried away with smoke into the chimney, where it is deposited on the cold pipes as a result of the temperature difference, and not settled soot is retained by a metal, fine-mesh filter grid. The soot which has settled on cold pipes periodically is cleaned off by means of a metal scraper and falls in the bunker for gathering of soot. The combustion ash is collected in a box for collecting ash located under the grate.



a) is a diagram of a plant for producing soot; b) - general view of the soot plant

Figure 3: Installation for receiving carbon soot

3.4. Mouthpiece Briquetting Laboratory Unit

The design of the mouthpiece briquetting laboratory is shown in Figure 4. The installation includes a bed, a press head, a pressing mechanism and a drive. The base serves as the basis for all moving parts of the press.

The head of the installation places molds in which the briquetting itself is carried out. The head is the most important part of the briquetting plant, which determines the intensity of pressing. It consists of a massive cast bed and a lid, connected together by tightening bolts.

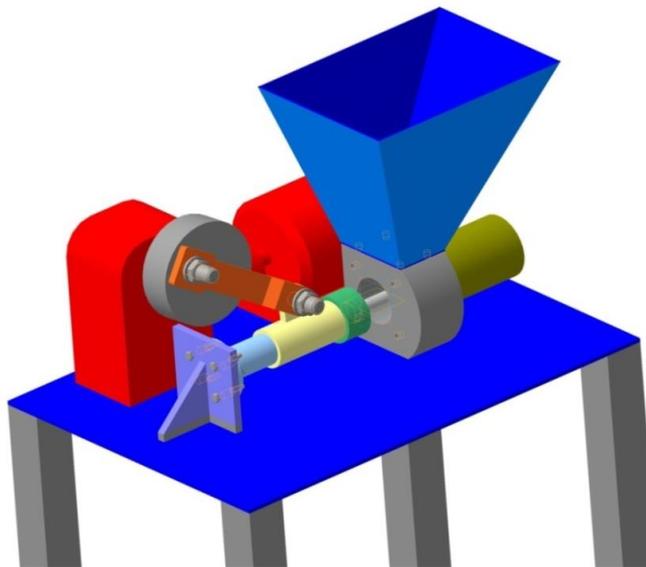


Figure 4: Construction of the mouthpiece briquetting laboratory unit

3.5. Designing a Briquetting Press

The authors of the project proposed the design of a roller press, in which the "non-working area" of the bandage surface is minimized by increasing the number of working cells and, as a consequence, reducing the energy costs on the drive of the machine.

Figure 5 shows the design of the roll assembly, which consists of a shaft 1, a disk 2, a shroud 3. The assembled assemblies are a shaft and disks, mounted on the shaft with a keyed connection and rigidly welded. Bandages 3 are cast rings with working semi-cylindrical sockets of a width equal to the length of future briquettes and fitted to discs.

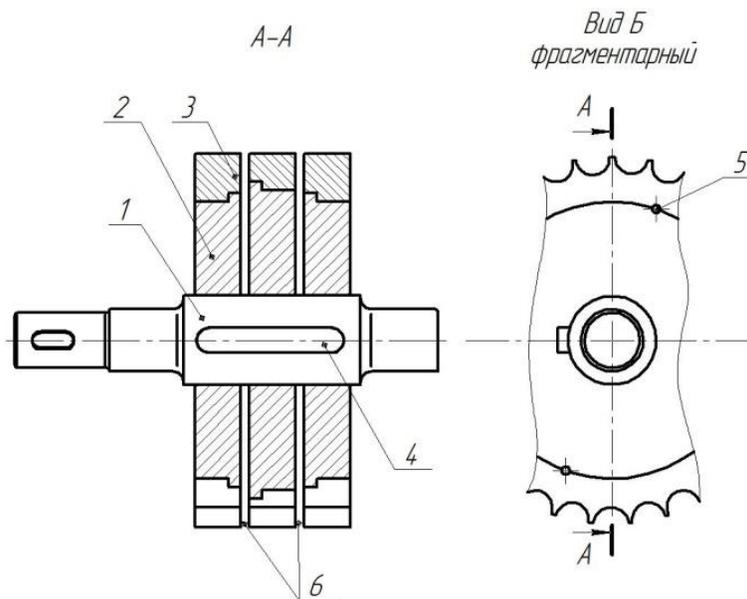


Figure 5: Design of the swath assembly

Figure 6 shows the construction of the filling frame. The filling frame is mounted above the rollers and is attached to the metal structures of the press. The frame is made of sheet steel with a thickness of 10 mm and is a welded metal frame consisting of two longitudinal sidewalls 1 and two transverse sidewalls 2 with slots 3 welded by lugs 4.

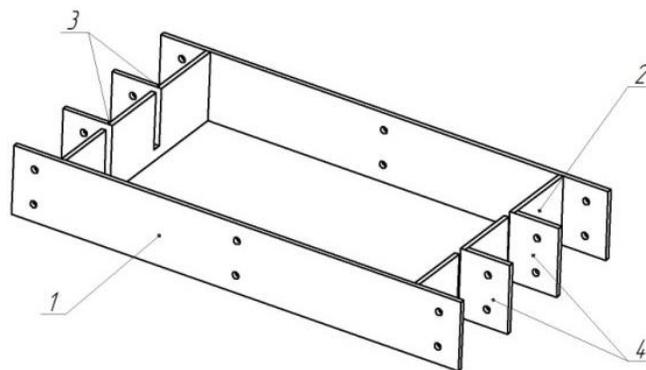


Figure 6: Construction of the filling frame

Figure 7 shows the attachment of the filling frame to the metal structures of the press. To the filling frame on top are fastened screws with countersunk heads external textolite side walls 1. From the bottom of the sidewall 1 are attached to the metal structures of the press brackets 2.

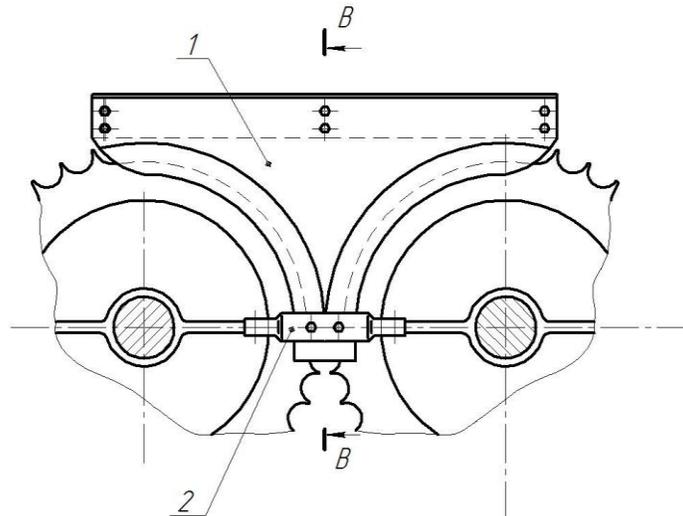


Figure 7: Fixing the filling frame to the metal structures of the press

Internal textolite partitions with slots are installed in the slots of the frame and fastened to the eyelets of the frame with bolts. Briquettes are formed in the working cells of the shrouds in the form of semicylindrical nests located immediately after each other with a width equal to the length of the future briquettes when the mixture is distributed between the textolite plates.

The roll press for briquetting bulk materials works as follows. The mixed initial components for the production of briquettes are fed into the filling frame, and then, through internal partitions in the filling frame, are divided into several streams to produce briquettes and fed into the working space of the briquette forming section between the rollers, where their final shape and necessary strength are formed due to compression.

The technical result is achieved by the fact that the press roller assembly comprises rollers mounted in the housing rotating towards each other, a charging hopper and a pre-pressing mechanism, characterized in that a pre-compacting mechanism of the briquette mixture consisting of a rod, a ramming shoe, a hinge, a connecting rod, a drive on the crankshaft, a flywheel, a pulley with a V-belt drive and a geared motor.

Figure 8 and Figure 9 show the general view of the press roll aggregate assembly. The roller press assembly contains a hopper-distributor 1 installed between the hopper 16 and the roll pairs 14. At the bottom, the hopper is bordered by a frame 15. Inside the hopper there is a cutter with chamfered walls 2. Between the bevelled walls is a pre-seal lever mechanism briquette mixture.

Figure 8 shows the pre-seal lever mechanism consisting of the stem 5, the ramming pad 13, the hinge 11 and the connecting rod 10. The connecting rod is mounted on the crankshaft 12 of the drive, which rotates from the geared motor 19 via a pulley with a V-belt drive 18. The crankshaft rests on bearings 17 and at the other end has a flywheel 21. All movable parts are covered with a casing 25.

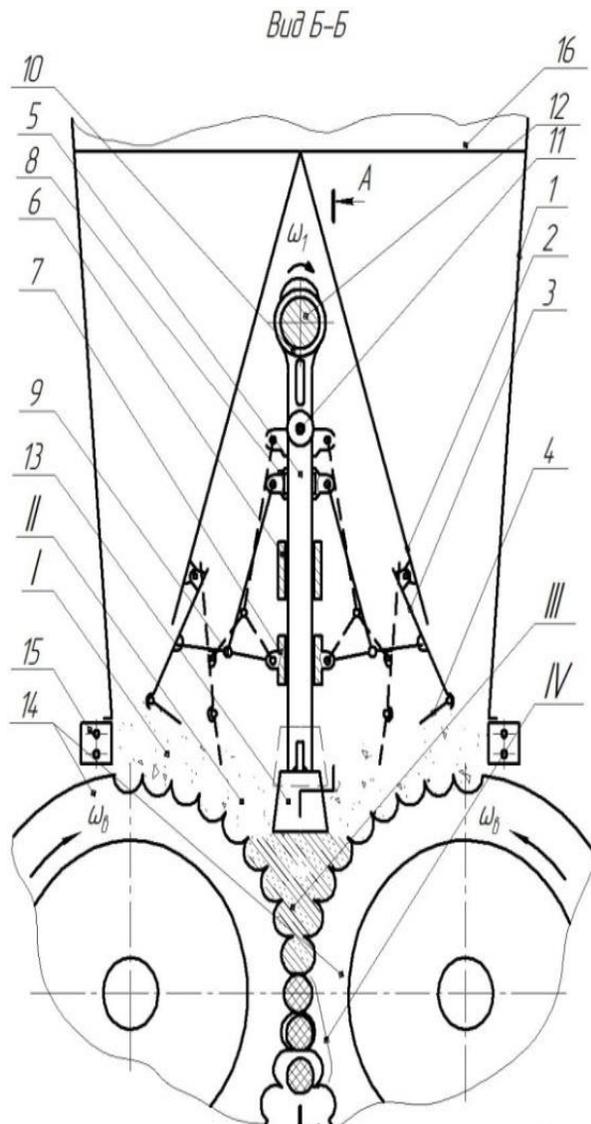


Figure 8: The pre-seal lever mechanism

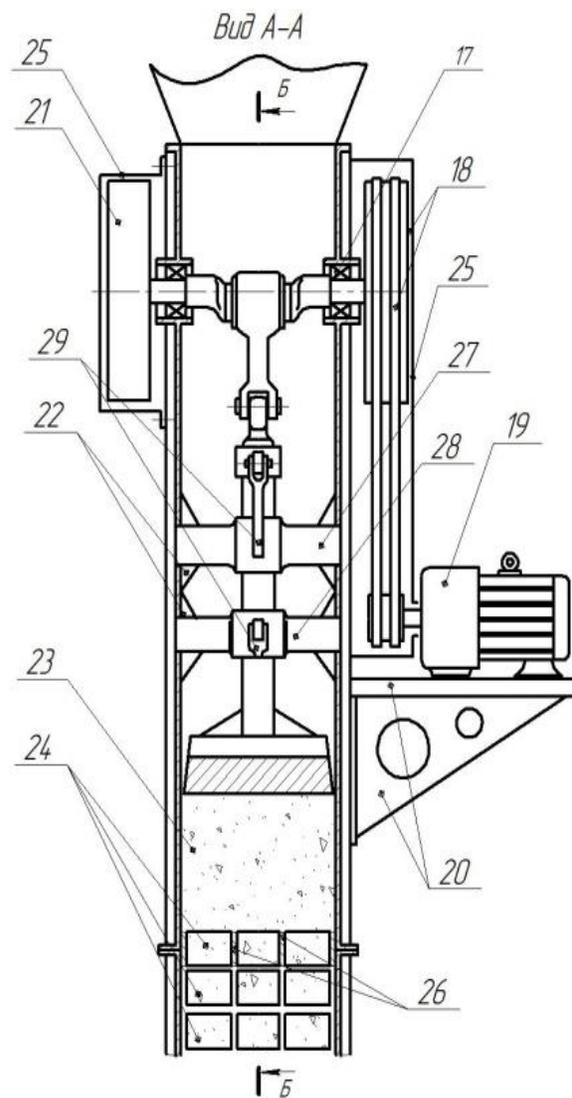


Figure 9: General view of the press roll aggregate assembly

Press roller assembly works as follows. The briquette mixture is supplied from the hopper 16 to the hopper-distributor, where it is separated by a divider into two streams and lowered into the feed zone of the mixture I. When the crank shaft 12 rotates, the connecting rod 10 drives the rod 5 back and forth along the sleeves 6, 7. At the same time, to the stem, the movable bracket forms a system of levers with a central hinge 9, which drives the internal movable walls 3 of the shaft. The movable walls 3 at one end pivotally connect to the inner fixed walls of the shaft 2 and on the other end are hingedly connected to the folding scrapers which, when the movable walls move to the starting position, change the angle "fold", and straighten and rake the mixture into the forced backfilling zone during the working stroke II. The briquette mixture under the impact of the shoe 13 is sealed in the pre-consolidation zone III, thereby ensuring the final wet strength of the briquettes leaving the rolls 24.

4. Conclusions & Recommendations

During the reporting period, the following results were obtained.

- 1) The characteristics of briquettes on bio-binding and on petroleum pitch have been established.
- 2) 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).
- 3) The technology of manufacturing briquettes on bio-binding and petroleum pitch has been developed.
- 4) The design of the soot separator, sorting and screening equipment, a mixing laboratory plant, a mouth-briquetting press, a roller briquetting press and a screw mixer with a heater has been developed.
- 5) Based on the results of the research, the project manager and co-authors published 15 scientific publications, patents and theses of international conferences.
- 6) The most economically acceptable area for the use of briquettes has been identified: briquettes for bio-binding can be used as fuel for combustion in centralized village boiler houses, private houses and farms; 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.
- 7) 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.
- 8) 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.
- 9) It is revealed that the calorific value of briquettes is higher than that of Ekibastuz coal by 20-40%, and the heating value (-DH0 combustion = 6840.8 kcal / kg) is the highest for briquettes with an enrichment agent in the form of anode dust and a binder in the form of petroleum pitch.
- 10) The design of the soot separator, sorting and sifting equipment, mixing laboratory equipment, mouth-briquetting press, roller briquetting press and screw mixer with heater has been developed.
- 11) The design of the soot separator, sorting and sifting equipment, mixing laboratory equipment, mouth-briquetting press, roller briquetting press and screw mixer with heater has been developed.
- 12) 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.
- 13) Soot was used in the rubber, high-quality carbon content in which reaches 96 - 98%. To obtain 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%.

- 14) 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%.
- 15) It has been 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 enrichment agent in the form of anode dust and a binder in the form of oil pitch (-NH combustion = 6840.8 kcal / kg) .

References

- [1] Decree of the President of the Republic of Kazakhstan from August 1, 2014 No. 874 "On approval of the State Program for Industrial and Innovative Development of the Republic of Kazakhstan for 2015-2019 and on the addition of the Decree of the President of the Republic of Kazakhstan dated March 19, 2010 No. 957" On Approving the List state programs ".
- [2] Resolution of the Government of the Republic of Kazakhstan of June 28, 2008, No. 644. About the Concept of the Development of the Coal Industry of the Republic of Kazakhstan for the Period to 2020.
- [3] Abdrakhmanov, Ye. S. P. O. Bykov, A. V. Bogomolov, N. K. Kulumbayev, R. B. Mukanov Ecological aspects of the use of Ekibastuz high-ash coal, Materials of the 11th International Scientific and Practical Conference Prospects of World science, Technical Science, - Sheffield; Science and Education Ltd 2015, 10, 5-7.
- [4] Abdrakhmanov, Ye. S. P. O. Bykov, A. V. Bogomolov, A. B. Kuandykov Experimental researching of fuel briquettes, Materials for XIII international scientific practical conference "Novinata for science-foreseen - 2017", Modernize information technology. Physics. Technical science. Mathematics. Geography and geology. Construction and architecture, 10, 3-6.
- [5] Abdrakhmanov, Ye. S. P. O. Bykov, A. V. Bogomolov, A. B. Kuandykov Researching of mixing quality of briquette mass, Materialy XIII Mezinarodnivedecko-praktickakonference, "Vedeckepokroknaprelomutysyachaletyichved - 2017", 22 - 30 kvetna 2017 on Chemie a chemicketechnologie. Technickevedy. Modernichinformachnichtehnologii. Geografie a geologie. - Praha: Publishing House "Education and Science", 2017. - 3 - 7.
- [6] Abdrakhmanov, Ye. S. P. O. Bykov, A. V. Bogomolov. Substantiation of the composition of briquettes during processing of Ekibastuz coal waste. Materials of the international scientific conference "Processing of industrial wastes as a pledge of ecological safety" 2016, Pavlodar:
- [7] Atiku F. A, E. J. S. Mitchell A. R. Lea-Langton, J. M. Jones, A. Williams, K. D. Bartle, The Impact of Fuel Properties on the Composition of Soot Produced by the Combustion of Residential Solid Fuels in a Domestic Stove 2016; 117-125
- [8] Nag, D R. Singh, S. Shome, P. K. Banerjee, V. K. Saxena, Use of organic binder in coke making; 2015, 112-116.

*Corresponding author.

E-mail address: erai1512@ mail.ru, bogomolov71@ mail.ru, bykov_petr@ mail.ru, azeka200892@ mail.ru

Appendices

Appendix A

Certificate of compliance of the chemical composition of coal briquettes

**«КӨМІР ХИМИЯСЫ
ЖӘНЕ ТЕХНОЛОГИЯ
ИНСТИТУТЫ» ЖШС**



**«INSTITUTE OF COAL
CHEMISTRY AND
TECHNOLOGY» LLP**

ТОО «ИНСТИТУТ ХИМИИ УГЛЯ И ТЕХНОЛОГИИ»

Астана қ., 181 к-сі, 10 ғым., ВП-3
 тел./факс: +7(7172)31-04-30, 999-253
 E-mail: coaltech@bk.ru
 № 04-02-16/40

г. Астана, ул. 181, здание 10, ВП-3,
 тел./факс: +7(7172)31-04-30, 999-253
 E-mail: coaltech@bk.ru
 « 23 » сентяб 2016 г.

Сертификат
О соответствии химического анализа

Настоящий сертификат удостоверяет, что результаты химического анализа на углерод (С) в угольных брикетах и расчет энтальпии сгорания угольных брикетов действителен

№ брикетов	Содержания углерода, %	- ΔН _{сгорания} КДж/кг	- Δ Н _{сгорания} Ккал/кг
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

Расчет ΔН_{сгорания} проведен из экспериментальных данных по энтальпии сгорания углей разреза «Северный» Экибастузского бассейна по формуле:

$$\Delta H_{сгор} = 17161 - 671,5 (\%C), \text{ кДж/кг}$$

Руководитель,
д.х.н., проф.



Ермагамбет Б. Т.



Исполнитель:
Бижанова Л.Н.
8(7172)310430

№ 0000175