DOI: 10.31489/2019Ph4/85-88

UDC 662.8: 678.8

E.S. Mustafin, Kh.B. Omarov, K.M. Shaimerdenova, A.T. Omerkulov

Ye.A. Buketov Karaganda State University, Kazakhstan
(E-mail: gulzhan.0106@mail.ru)

Production of coal briquettes using the original binder

In this paper the authors consider a new genuine binder that makes it possible to produce coal briquets with desired consumer properties, i.e. reduced bitumen consumption, low production process temperatures and high moisture resistance. To make coal briquets, a batch mixture was prepared (coal fines, slack, riddlings) and then mixed in a mixer with a genuine emulsified bitum in a ratio of 20 to 1 by weight, after which the mixture was fed into molds and taken to a pressing machine. The resulting briquets were dried at a temperature of 30–40 ºC for 12 hours. The results of their tests displayed a compressiion strength of 60–70 kg/cm^2; when dropped from a height of one meter, the residue on the sieve +25 mm after sieving was 96–98 % (high strength). In addition, the briquets showed good resistance to moisture (low moisture capacity not more than 2–3 %) — water sprinkling did not loose the briquettes; there was no destruction even when doused into water. In the process of burning the briquets did not disintegrate, the flame was uniform in all directions. Calorific capacity tests of the produced briquets were made. Due to the improved commercial quality offered by briquees, after scoping calculations the saving of coal fuel was presupposed.

Keywords: coal briquettes, coal fines, mixture, slack, bitumen, moisture resistance, binder, calorific capacity.

The strategic objectives of the development of coal chemistry are reliable and effective satisfaction of domestic demand for high-quality solid fuel and its products, ensuring the competitiveness of coal products in the conditions of saturation of domestic and foreign markets with interchangeable energy resources and alternative suppliers, improving the safety of coal processing and reducing their impact on the environment.

As a result of the activities of enterprises for the extraction and beneficiation of coal, there is a need to recycle the inevitable waste (coal fines, riddling and milling slime, etc.), which are practically not used.

One of the methods of such processing is briquetting. Briquetting is the process of processing fine coal and slack into pieces of a geometrically regular and uniform shape, and of equal mass — briquettes. Coal briquettes are very easy to use due to simple placing, high flammability, and constant caloricity even during long-term storage, ease of accounting and control in use. Every year production of briquettes develops more and more, as during transportation the briquettes are not destroyed due to the strength obtained in the manufacturing process. Usually coal is transported in bulk in open wagons, and with one loading (unloading), the volume of coal in the car decreases by 10 %, and if we take into account the number of coal transfer upon delivery to the consumer, the volume decreases by 15–25 %. Ordinary coal does not burn completely in furnaces and fire pots — fine coal is spilt through fire bars into an ash pan, and this is about 10 % of the total weight of the poured coal; when burning, pieces of coal break up, releasing coal dust that flies out in fly ash, so losses can reach 25–35 %. Unlike coal, briquettes burn completely, there is no refuse burnout and only ash remains after combustion [1].

The need to process waste (coal fines) arising from the activities of enterprises for the extraction and enrichment of coal, to obtain liquid products, the sale of which will allow a more complete use of mineral reserves, to save products and improve the productivity of the coal industry requires the development of new briquetting technologies. Briquetting is the process of processing coal fines into pieces geometrically correct and uniform shape, the same mass-briquettes.

The influence of briquetted charge humidity on the strength characteristics of fuel briquettes and the optimal humidity value equal to 4.9 % was established.

We can assume the following stages of the process of coal briquetting with binders:

– adsorption of binder by briquetted material and formation of thin binder film on particle surface,
– pressing processes, during which, under the influence of pressure, hardening processes occur at the interface of the binder phases with the surface of coal,
– formation of a structuring polycyclic complex or polymer layers around a granular carbon-containing component that determine the strength and other technical characteristics of fuel briquettes.
– formation of own structure of briquettes and hardening, accompanied by dehydration and drying processes [2].

The imported coal has in its volume a certain amount of rock and debris, which are added to the loading and unloading stations. During the production of briquettes, coal raw materials are cleaned of rock and other impurities by sieving.

Currently, the main reasons inhibiting the development of briquetting of stone, brown coal and coal sludge is the lack of affordable and cheap binder. For this reason, constantly underway the search for different variants of individual or combined binders for obtaining fuel briquettes.

Currently, the development of briquetting binders has been divided into three categories: organic, inorganic and composite binders. However, the development of complex substances continues, in which the binder can take full advantage of all kinds of binder, fill the shortage of one binder, reduce the amount of inorganic binder, reduce the cost of briquettes, improve the quality of briquettes and greatly improve the strength. Given the development of modern research, the search for organic and organic-inorganic composition of binders has become a center of research and development. In particular, the composite binder consisting of industrial and agricultural waste mixed with other binders can reduce environmental pollution and improve the quality of the briquette, and have certain economic and environmental benefits at the same time. So in recent years, composite binder has become the main direction of development of briquette binder [3].

Selection of binders that simultaneously meet all the necessary requirements: availability, low cost, the ability to increase the heat of combustion of the obtained pieces of fuel and its moisture resistance, the ability to give the briquette high mechanical strength, etc.

In the modern technology of briquetting of coal fines with the addition of bitumen binder, the strength of the briquette after pressing is determined by technological regimes, in particular the pressing temperature, and depends on the structure and properties of bitumen [4].

The purpose of the proposed work is to expand the existing range of binders that allow creating a fuel coal briquette with the necessary consumer properties, which imply a reduction in bitumen consumption, lower process temperatures and moisture resistance.

Bituminous emulsion (composite material) was used to bind fine coal, which showed good adhesive qualities and was operated for three years during the pretreatment of the roadbed for asphalt laying. The resulting emulsion has plasticity, fluidity, relatively good adhesion (stickiness), hydrophobic, short preparation times and good combustibility. Due to the content of the polymer (cross-linked) composition, the proposed water-emulsion mixture binds coal fines well and has increased strength characteristics [5].

The main advantages of using the proposed emulsion in comparison with other binders are the availability of a ready production plant, relatively low energy consumption, the use of local raw materials and low-cost reagents.

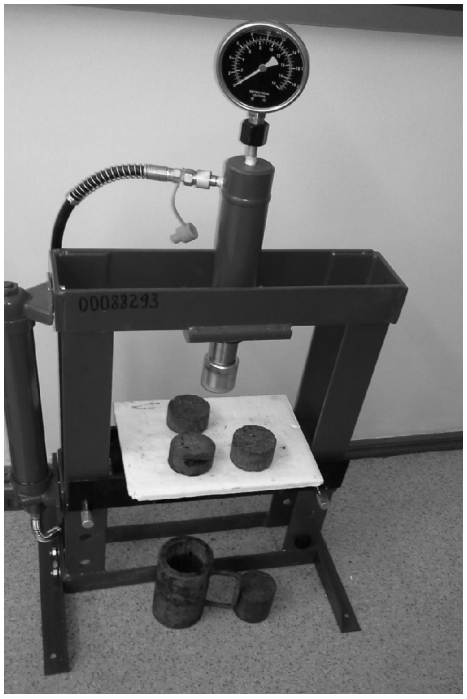

Figure. Photo of obtained coal briquettes

The batch mixture (coal fines, slack, riddling) intended for briquetting heated to the temperature of 60–70 ºC was mixed in a mixer with emulsified bitumen prepared at a temperature of 90 ºC in a ratio of 20 to 1 by weight, after which the mixture was loaded into molds and fed into pressing machine with a working pressure of 100–200 MPa. The resulting briquettes were dried at a temperature of 30–40 ºC for 8 hours.

As a result of mixing, the binder covered coal particles in thin layers (film) with hydrophobic properties, and provided the necessary adhesion of particles, and then during dehydration, polymerization took place; the latter process cemented the coal particles in briquette mass.

Briquettes were tested according to GOST 21289-75-21289-91 «Briquettes coal. Methods of physical tests» (see Fig.).

Obtained fuel briquettes according to the test results:

– have a compressive strength of 65–70 kg/cm^2;

– when dropped from a height of 1 m, the residue on the sieve +25 mm after sieving was 96–98 % (high strength);

– have good resistance to moisture (low moisture capacity of not more than 2–3 %) — irrigation spraying did not loosen the briquettes;

– no destruction when immersed in water;

– in the combustion process, the flame was uniform in all directions and the briquettes disintegrated.

The performed tests on the calorific value are GOST 147–95 «Solid mineral fuel. Determination of the highest heat of combustion and calculation of the lowest heat of combustion» showed improvement of properties of briquetted coal in comparison with the initial raw materials taken from different coal enterprises (see Table).

T a b l e

Test results of small fractions and obtained briquettes

Name and measurement units	Results					
	Small fraction from coal enterprises			Briquette		
	1	2	3	1	2	3
Mass fraction of total moisture in operating condition of fuel, %	5.7	7.5	5.4	3.6	5.6	2.9
Ash content, %	34.5	39.9	32.3	34.4	36.3	32.4
Mass fraction of total sulfur	0.50	0.6	0.5	0.45	0.55	0.5
The lower heating value, based on the operating condition of the fuel, kcal/kg	4885	4560	4090	5100	4650	5154
Higher heating value calculated for dry ash-free fuel, kcal/kg	7860	6960	7210	8220	6990	8381

Notes: *1* — sludge from the «Saburkhanskaya» central processing plant; *2* — coal fines from the Borly deposit; *3* — coal fines from the «Kuu Chekinsky» surface coal mine.

Due to the improved commercial qualities of the proposed briquettes, after preliminary calculations, the following saving of coal fuel was presupposed:

– up to 10 % during transportation and overloading due to high mechanical strength (M35≥80 %);
– up to 10 % during transportation and overloading due to high mechanical strength;
– up to 14 % during combustion due to avoiding carrying away of coal fines by flue gases and spillage of the fuel through the grate;
– up to 11 % due to elimination of under-burns due to high reactivity and thermal stability.

The main advantages of the proposed method of coal briquetting are the following:

– the briquette has high strength and moisture resistance (it can be stored in open areas);
– it turns out to be smoother and cleaner than conventional coal and other briquettes;
– bitumen consumption decreases by 75–85 %;
– reduced energy consumption, due to lowered operational temperature of the production process — 60–80 ºC;
– losses during loading and unloading operations are reduced due to the high strength and cylindrical shape of briquettes;
– small production costs, due to the low cost of the emulsion (binder).

As a result of the tests, it was noted that the produced briquettes meet the standards, have increased moisture resistance, are resistant to mechanical stress and have a higher calorific value compared to the original raw material. Coal briquettes made using the genuine binder are easy-to-use due to the simplicity of their storage, fairly high flammability, the invariance of their calorific value during storage, moisture resistance and ease of control during consumption. Coal briquettes produced with the original binder are easy to handle due to the simplicity of laying, fairly easy flammability, and immutability of their calorific value during storage, moisture resistance and ease of control during consumption.

References

1 Елишевич А.Т. Брикетирование угля со связующими / А.Т. Елишевич. — М.: Недра, 1972. — 160 с.

2 Tulepov M.I. Preparation of Coal Briquettes and Determination of Their Physical and Chemical Properties / M.I. Tulepov, L.R. Sassykova, A.R. Kerimkulova, G.O. Tureshova, D.M. Tolep, A.O. Zhapekova, Z.A. Mansurov // Oriental Journal of Chemistry. — 2019. — No. 35(1). — P. 180–185. DOI:10.13005/ojc/350120.

3 Zhang G.J. Review of briquette binders and briquetting mechanism / G.J. Zhang, Y.H. Sun, Y. Xu // Renewable & Sustainable Energy Reviews. — 2018. — Vol. 82. — P. 477–487.

4 Петрова Л.А. Получение бытовых топливных брикетов с использованием нефтяных связующих / Л.А. Петрова // Нефтегазовое дело (электрон. науч. журн.). — 2007. — № 1. — 14 с.

5 Мустафин Е.С. Способ получения битумной дорожной эмульсии с использованием каменноугольного битума / Е.С. Мустафин, К.К. Ташмагамбетов, Р.З. Касенов // Патент РК № 12–3/89 от 22.01.13 г.

Е.С. Мустафин, Х.Б. Омаров, К.М. Шаймерденова, А.Т. Омеркулов

Бастапқы байланыстырушы затты қолдана отырып, көмір кесектерін алу

Мақалада қажетті тұтынушылық қасиеттері бар көмір брикеттерін жасауға мүмкіндік беретін жаңа бастапқы байланыстырушы зат қарастырылған, яғни, битумның шығынын азайту, технологиялық процесс температурасының төмендеуі және ылғалға төзімділігін. Брикеттеу үшін шихтаны (көмір қалдықтары, шлам, бөліктер) дайындап, содан кейін қоспаны массасы бойынша 20:1 қатынасында түпнұсқалы битум эмульсиясымен араластырды, содан кейін қоспа пресс қалыптарға тиеліп, баспаққа берілді. Алынған брикеттер 30–40 ºС температурада 12 сағат бойы кептірілді. Сынау нәтижелері 60–70 кг/см^2 қысуға беріктігін көрсетті, бір метр биіктіктен лақтыру кезінде, елегеннен кейін ситадағы +25 мм қалдық 96–98 % (жоғары беріктігі) құрады. Сонымен қатар, брикеттер ылғалға жақсы төзімділігін көрсетті (ылғал сыйымдылығы 2–3 %-дан аспайтын төмен) — бүрку арқылы брикеттерді қопсытпады, қираған және суға батқан кезде болған жоқ. Өрт кезінде брикеттер құлап қалмады, жалын барлық бағыттар бойынша біркелкі болды. Алынған брикеттерге жылу шығарғыштығы бойынша сынау жүргізілді. Алдын ала есептеуден кейін, брикеттер ұсынған жақсартылған тауарлық қасиеттер есебінен көмір отынын үнемдеу болжамды.

Кілт сөздер: көмір брикеттері, көмір қалдықтары, шихта, шлам, битум, ылғалға төзімділік, байланыстырушы заттар, жылу шығарғыштық.

Е.С. Мустафин, Х.Б. Омаров, К.М. Шаймерденова, А.Т. Омеркулов

Получение угольных брикетов с применением оригинального связующего вещества

В статье рассмотрено новое оригинальное связующее вещество, которое позволяет создать угольные брикеты с нужными потребительскими свойствами, т.е. уменьшение расхода битума, понижение температур технологического процесса и влагостойкость. Для брикетирования готовили шихту (угольная мелочь, шлам, отсев) и затем смешивали в смесителе с оригинальной битумной эмульсией в соотношении 20 к 1 по массе, после чего смесь загружалась в пресс-формы и подавалась в пресс. Полученные брикеты сушились при температуре 30–40 ºС в течение 12 ч. Результаты испытаний показали прочность на сжатие 60–70 кг/см^2, при сбрасывании с высоты одного метра остаток на сите +25 мм после просеивания составил 96–98 % (высокая прочность). Кроме того, брикеты показали хорошую устойчивость к влаге (низкая влагоемкость не более 2–3 %) — орошение опрыскиванием не разрыхляло брикеты, отсутствовали разрушения и при погружении в воду. В процессе горения брикеты не распадались, пламя было равномерное по всем направлениям. Проведены испытания полученных брикетов по теплотворности. За счет улучшенных товарных качеств предлагаемых брикетов после предварительных расчетов была предположена экономия угольного топлива.

Ключевые слова: угольные брикеты, угольная мелочь, шихта, шлам, битум, влагостойкость, связующее вещество, теплотворность.

References

1 Elishevich, A.T. (1972). *Briketirovanie uhlia so sviazuiushchimi [Coal briquetting with binders]*. Moscow: Nedra [in Russian].

2 Tulepov, M.I., Sassykova, L.R., Kerimkulova, A.R., Tureshova, G.O., Tolep, D.M., & Zhapekova, A.O., et al. (2019). Preparation of Coal Briquettes and Determination of Their Physical and Chemical Properties. *Oriental Journal of Chemistry*, *35(1)*, 180–185. DOI:10.13005/ojc/350120.

3 Zhang, G.J., Sun, Y.H., Xu, Y. (2018). Review of briquette binders and briquetting mechanism. *Renewable & Sustainable Energy Reviews, 82*, 477–487.

4 Petrova, L.A. (2007). Poluchenie bytovykh toplivnykh briketov s ispolzovaniem neftianykh sviazuiushchikh [Production of household fuel briquettes using oil binders]. *Neftehazovoe delo — Oil and Gas Business*, 1, 14 [in Russian].

5 Mustafin, E.S., Tashmagambetov, K.K., & Kasenov, R.Z. (2013). Sposob polucheniia bitumnoi dorozhnoi emulsii s ispolzovaniem kamennouholnoho bituma [Method for producing bitumen road emulsion using coal bitumen]. *Patent RK No. 12–3/89* Dated 01.22.13.