Processing of Low-Demand Coal and Other Carbon-Containing Materials for Energy Production Purposes

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Abstract

The main area of coal application is energy production. During such stages as min-ing, transporting, treatment, storing and processing of coal, a large number of small products are formed, such as screenings, spills, sludges, etc. Such products are not used and significantly pollute the environment. Meanwhile, after agglomeration, they can eas-ily be used for the production of thermal energy. Of all the known agglomeration meth-ods, briquetting is most suitable. The technology of obtaining flammable briquettes based on coal is developed. A technology has also been developed to produce fuel bri-quettes from coal slurries and paper waste. The use of coal slurries and paper waste as binder materials makes it possible to obtain a fuel pellet that is simple in production and composition and at the same time allows to utilize coal and paper wastes. The technolo-gy of obtaining fuel extrudates (briquettes) from wood and shale wastes, as well as wood, shale waste and sludge was developed. Thus, technologies have been developed to produce fuel briquettes from various types of low-demand carbon-containing materi-als for domestic use.

Keywords: low-demand carbon-containing raw materials, briquetting, fuel briquettes, coal sludge, paper waste, waste woodworking, waste shale

Introduction

Despite the wide range of coal applications (cast iron, production of germanium, gal-lium and other elements, etc.), it has been and still remains the most important energy source. For example, from coal, it can get an effective type of fuel – coal gas [O.A. Dubovikov, V.N. Brichkin, D.A. Loginov, 2016; O.A. Dubovikov, V.N. Brichkin, 2016].

During such stages as mining, transporting, treatment, storing and processing of coal, a large number of small products are formed, such as screenings, spills, sludges, etc [V. Yu. Koptev, A.V. Kopteva, 2018; K. R. Argimbaev, H. A. Kholodjakov, 2016; M.N. Kruk, V.R. Alabyev, M.A. Korobitcyna, I.S. Stepanov, 2016]. Such products are not used and significantly pollute the environment due to accumulation of their vast re-serves. Meanwhile, in terms of their energy characteristics, they are usually not inferior to the coal being mined and with appropriate processing can be used to produce thermal energy.

Also for the production of thermal energy carbon-based materials such as paper, wood, slate waste and the like can be used.

Direct burning of the above-mentioned materials is difficult and ineffective because they are represented by small particles, which mean that they must be agglomerated first. Of all the known agglomeration methods, the most suitable is briquetting [A.T. Eleshevich, 1990].

Briquette production allows: to obtain high-quality and transportable fuel from mate-rials that are not used at present. Also that helps to partially solve the environmental problem at the same time.

Research work on briquetting

A technology was developed to produce household fuel briquettes with a low ignition temperature, ignited from low-energy heat sources (for example, matches) on the basis of coal. The production of such briquettes is possible, for example, by creating briquettes with a main part, a source of heat energy, and a special incendiary part. The ignition part can be ignited, for example, from the match, then ignites the main part. Briquettes were produced using various types of organic binders. To increase the completeness of com-bustion and reduce harmful emissions into the atmosphere, briquettes were produced with through perforation. The form of briquettes can vary within wide limits [V.B. Kus-kov, Y.V. Kuskova, D.V. Sukhomlinov, 2013].

A complex of studies was also carried out in which coal slurries and paper wastes were used as carbonaceous components of the charge. The use of coal slurries and paper waste as carbon-containing components makes it possible to obtain a simple fuel-briquette in the manufacture and composition and simultaneously utilize coal and paper waste. Coal slurries increase the calorific value of the fuel briquette. Paper waste is both a binder and a fuel component. The moisture content of the initial charge is 8–10%. Bri-quettes were formed by extrusion. The briquette has a longitudinal hole, the cross-sectional

area of which is from 25 to 40% of the cross-sectional area of the briquette, which improves its combustion. The presence of a hole with a cross-sectional area of less than 25% of the cross-sectional area of the briquette reduces the completeness of com-bustion of the briquettes due to insufficient air flow. The presence of a hole with a cross-sectional area of more than 40% does not increase the completeness of combus-tion, excessively increases the volume of the briquette (without increasing the caloric content), lowers the strength of the briquette. The sizes of briquettes can vary within ra-ther wide limits. The optimal amount of coal slurries in the briquette is 30–60%, and of paper waste – 40–70%. If the content of coal slurries exceeds 60%, the strength of the briquette decreases, and they become more difficult to ignite. If the content of coal slur-ries is below 30% and paper waste is more than 70%, the calorific value of the fuel bri-quette is reduced. The mechanical strength of the briquettes was determined as the number of falls from a height of 1.5 m (this is twice the maximum overload height) that the briquettes withstood. The resulting briquettes showed sufficient mechanical strength. After ten drops from a height of 1.5 m, the amount of fines (a class smaller than 5 mm) did not exceed 3%.

There were also briquettes in which there was a special ignition layer (containing, for example, nitrates) which is easily ignited from low-energy sources of heat (for example, matches), then combustion is spread to the main part of the briquette. The briquettes were formed by an extruder having mixing and pressing zones. The nitrates were pressed into the base layer in a dry form, into the outer surface of the briquette due to the work of an additional screw of the bracer. In the pressing zone, the briquette is strengthened and leaves the extruder having a strength sufficient to transport it to the dryer. The briquettes after drying are easily ignited, burned steadily and did not actually emit smoke. Such a briquette is very convenient to use. It is also possible to use both types of briquettes with an incendiary layer and without it at an approximate ratio of 1:10. In this case, a highly inflammable briquette with an incendiary layer, ignites bri-quettes without an incendiary layer. At the same time, significant savings are achieved, because briquettes with an incendiary layer are more expensive than without it [V.B. Kuskov, Y.V. Kuskova, D.V. Sukhomlinov, 2013].

Relatively often coal slimes have an increased ash content. In this case, the sludge is concentrated, for example, on a concentration table, on a short-cone hydrocyclone, a spi-ral separator ets. In addition, these processes significantly reduce the sulfur content in the product [V.B. Kuskov, Y.V. Kuskova, 2015; A. Nad, 2010].

Many small products are formed (chips, sawdust, dust collection products, etc.) dur-ing the wood processing. This is very wasteful materials because they are practically not used which leads to environment pollution and create a fire hazard. A similar picture is observed in the processing of oil shale. Both wood and shale waste can be used to pro-duce energy. One of the ways of processing this kind of wastes is their briquetting [B. V. Yuryevich, K. V. Borisovich, 2016].

The use of fuel briquettes and pellets with inclusions of wood waste increases every year. Recycling is now no less important for the manufacturer than the production itself. On the other hand, there is the problem of recycling waste from the extraction of com-bustible shale. But research has shown that briquettes made from slate wastes only have insufficient mechanical strength, since shale does not have bonding properties. There-fore, it is of scientific and technical interest to study the possibility of briquetting shale waste with wood and paper waste and using briquettes as alternative sources of heat. Authors conducted researches regarding creation of briquettes out of residual wastes from wood and oil shale processing In the production of briquettes, wood waste, wood dust, shale dust in various proportions were used as a charge. Experimental studies have shown that the optimal ratio of wood waste, wood dust and shale dust is from 10:40:50 to 20:60:20 [B. V. Yuryevich, K. V. Borisovich, 2016].

Design of flowsheet for briquetting

It also developed technologies for the production of fuel briquettes from wood waste, wood dust, oil shale dust, paper waste and coal sludge. Experiments have shown that the ratio of these components close to the optimum is 20: 10: 20: 20: 30, 15: 10: 20: 30.The Equipment flowsheet of briquette productionis shown in Fig. 1.

The feedstock for briquettes production is loaded into storage bunkers 1-4.From the bunker 1 by the screw feeder 5 material is fed to the screen 6. Large particles are screened out on the screen, which can serve as fuel. Fine product screening, wood dust, shale dust, paper waste conveyor conveyed to the mixer 7. Also in the mixer 7 coal slur-ries are fed. After mixing, the mixture feds to the forming device 8 (extruder). Raw ex-trudates arrives at screener 9. Extrudates with conditioned particle size are fed to the drying 12, and sub-standard ones are fed to conveyor system are brought back to the mixer 7. Driedextrudatesare sent to screener 13 and are divided there into smaller sub-standard size, which are sent back to mixer 7 by conveyor system, and rightly sizedex-trudates, which are transported to the warehouse.

Briquettes were molded by both "conventional" pressing and extrusion. The specific dimensions and shape of briquettes or extrudates can vary within very wide limits in ac-cordance with the requirements of the consumer.

The mechanical strength of the product, which is its most important consumer proper-ty (since the product needs to be transported) was defined as the number of falls from a height of 1.5 m that the briquettes withstood. The results of the tests of both raw and dry briquettes showed their sufficient mechanical strength. For example, raw briquettes withstood 3–4 drops without noticeable damage. Dry briquettes kept more than 10 falls.

It should be noted that usually the products of wood and slate processing are dry and in the process of mixing it is necessary to add water until the optimum moisture is reached, which is 8–10%. Then this water must be removed during the drying process. Coal slurries, on the contrary, are watered (this is one of the reasons why they are diffi-cult to process). Therefore, the addition of coal sludge, as a component of charge, allows us to solve several problems at once: creating optimal moisture, increasing the caloric content of the product, and utilizing slurries.

This technology is versatile enough. The technology allows to use a variety of types of carbonaceous materials as components of the charge of briquettes.

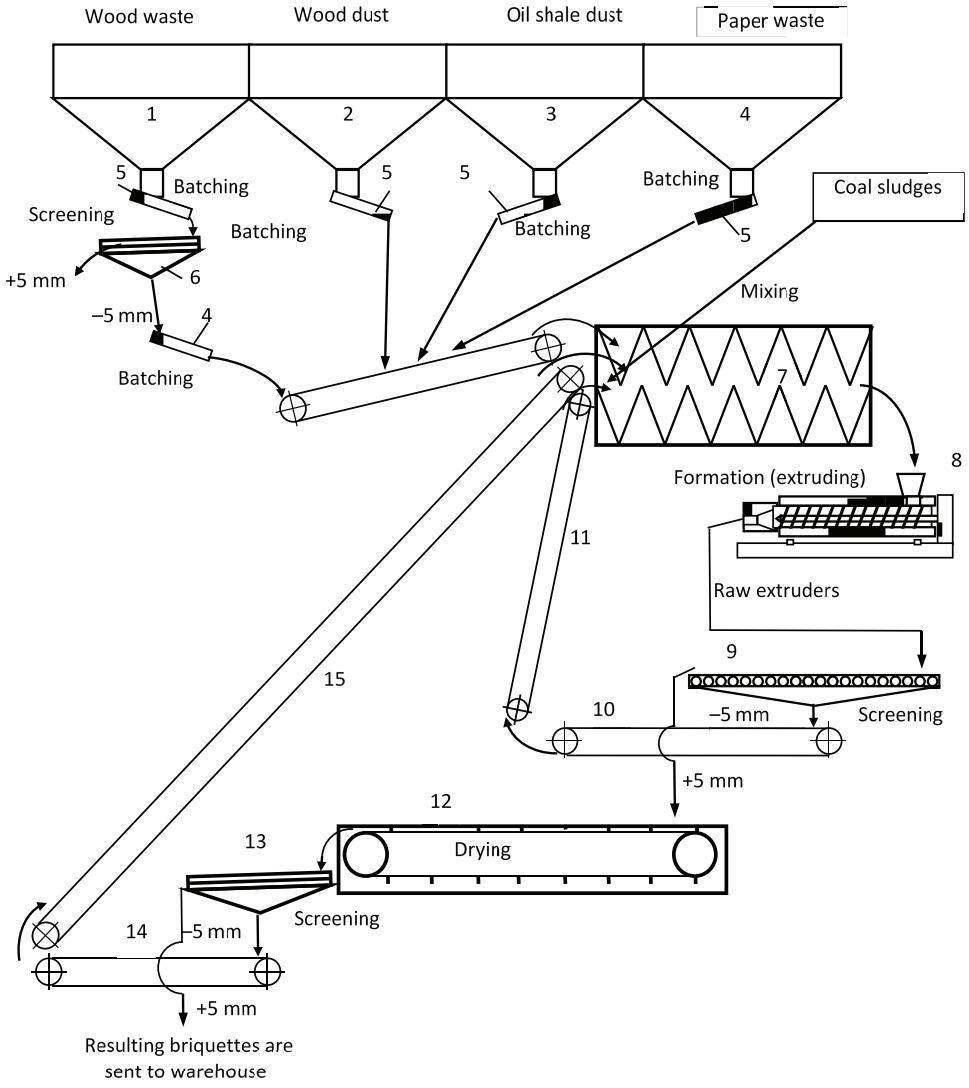

Fig. 1 Equipment flowsheet of briquette production
Rys. 1. Linia produkcyjna do produkcji brykietów

In such a flow sheet, the above-mentioned methods for removing ash from sludges are well suited. In this case, such equipment as hydrocyclone is compact and easily ac-commodated in any enclosure without increasing its dimensions.

The received briquettes are kindled like ordinary firewood. When burning, little smoke is emitted. They are more compact than conventional firewood, have a high spe-cific calorific value (calorie briquettes 4900–5940 kcal / kg), burn longer. Also, ash after burning briquettes may be an additional source of raw materials [R.Y. Feshchenko, O.O. Erokhina, V.L. Ugolkov, M.Y. Shabalov, V.V. Vasil'ev, 2017]. Thus, from products of wood processing, products of dust-catching processes of wood processing and shale processing and coal slurries, it is possible to obtain full-value energy products with their simultaneous utilization, which partially solves the environmental problem.

Conclusion

Developed technology for the production of fuel briquettes from of low-demand coal and other carbon-containing materials for energy production purposes. A technology has been developed for the production of household fuel briquettes with a low ignition tem-perature, ignited from low-energy heat sources (for example, matches). Also developed a technology for producing fuel briquettes from wood waste, wood dust, shale dust, pa-per waste and coal sludge. The production of such products allows to obtain additional amount of thermal energy and at the same time partially solves environmental problems.

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Przeróbka niskoenergetycznych węgli i innych materiałów zawierających węgiel do celów produkcji energii

Głównym obszarem zastosowania węgla jest produkcja energii. Podczas takich etapów, jak wydobycie, transport, przeróbka, magazynowanie i przetwarzanie węgla, powstaje duża ilość drobnouziarnionych produktów (szlamy, muł itp.). Takie produkty nie są wy-korzystywane i znacząco zanieczyszczają środowisko. Tymczasem po aglomeracji można je łatwo wykorzystać do produkcji energii cieplnej. Spośród wszystkich znanych metod aglomeracji, brykietowanie jest najbardziej odpowiednie. Opracowano technologię otrzymywania łatwopalnych brykietów na bazie węgla. Opracowano również technolo-gię produkcji brykietów paliwowych z zawiesin węglowych i odpadów papierniczych. Zastosowanie zawiesin węglowych i odpadów papierniczych jako materiałów wiążących umożliwia otrzymanie granulatu paliwa, który jest prosty w produkcji i składzie, a jed-nocześnie pozwala na wykorzystanie odpadów węglowych i papierniczych. Opracowa-no technologię pozyskiwania granulatów paliwowych (brykietów) z odpadów drzew-nych i łupkowych, a także drewna, odpadów łupkowych i mułu węglowego. Opracowa-no technologie wytwarzania brykietów paliwowych z różnych rodzajów materiałów wę-glowych o niskim uwęgleniu do użytku domowego.

Słowa kluczowe: surowce węglowe o niskiej zawartości węgla, brykietowanie, brykie-ty paliwowe, szlam węglowy, odpady papierowe, odpady drzewne, łupek odpadowy