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USE OF VARIOUS TYPES OF CARBON-CONTAINING RAW MATERIALS TO PRODUCE THERMAL ENERGY

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Many types of carbon-containing organic compounds and all possible carbon-containing products or wastes in low demand can be used to produce thermal energy.

A technology has been developed for producing highly flammable briquettes on the basis of bituminous coal. These briquettes have a special incendiary layer. It is easily ignites from low energy heat sources (e.g. matches), and then flame spreads to the rest of briquette.

Use of coal slacks and paper wastes as carbon-containing components playing the role of binders provides an opportunity to get a fuel briquette easy in terms of production and plain in composition while at the same time dispose of coal and paper wastes. Such briquettes may also have a special incendiary layer.

Technology for fuel briquettes production from wood and slate wastes employed no binding agents, as wood products acted as binders.

Thus technologies have been developed to produce fuel briquettes from various carbon-containing materials in low demand. The briquettes are intended for household boilers, fireplaces, different ovens in order to cook food, heat residential and utility premises, cabins, etc.

Key words: carbon-containing raw materials in low demand, briquetting, fuel briquettes, coal slacks, paper wastes, industrial wood wastes, industrial slate wastes.

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Introduction. Many types of solid carbon-containing organic compounds and all possible carbon-containing products or wastes in low demand can be used to produce thermal energy. The most important one is coal, which reserves on our planet are enormous (by far exceeding oil and gas reserves). The coal mining, transportation, beneficiation, storage and processing is associated with huge amounts of various wastes and low-demand products, generally the fractions are quite small (screenings, spillage, slacks, etc.). When they are used for heating most part of fuel is wasted through grizzly openings. Some coal gets baked preventing air access to the furnace while combustion rate falls down. That is the reason why such products are usually not used and become environment pollutants. As of today their reserves are huge. Though their quality is usually not worse than that of the fossil coals.

In addition we have investigated a possibility to produce thermal energy from such carbon-containing materials, as paper, wood and slate wastes. These wastes are also of low-size range.

The most affordable and the most studied from technical perspective is processing of the aforesaid low-demand products and wastes by briquetting with binding agents. Briquetting means mechanical or thermomechanical processing of coal fines, concentrates and industrial wastes to form them into briquettes - blocks of regular shape and consistent dimensions. Briquetting differs from other agglomeration methods by its simplicity and cheap price [1, 3, 4, 18].

By their application fuel briquettes can be household and industrial. Industrial briquettes are used as raw materials for semicoking and coking and as industrial fuel. Coal briquettes can perform the function of heat insulating material and the main raw material for production of various kinds of electrodes.

Briquette production offers the following benefits: high rank and transportable fuel of improved quality; reduced coal losses during storage, transportation and combustion; prevention of coal spontaneous ignition; use of nonbaking coal as an additional resource for coking; use of low-quality local fuels; increase in the rate of brown coal extraction for its use as a source of energy and for technological processing; use and thus reduce different wastes, in particular organic ones.

The paper considers a possibility to produce household fuel briquettes from different types of carbon-containing raw materials. The major consumer of the household briquettes is the population.

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Research Undertaken. A technology was developed to produce a special type of fuel briquettes with low ignition temperature lighted from low-energy thermal sources on basis of bituminous coal. Such briquettes may have the main part being a source of thermal energy and a special incendiary part. The incendiary part may be lighted for example with a match and then ignite the main part. The briquettes have been produced using different organic binders. In order to improve the combustion efficiency and reduce air polluting emissions the briquettes were perforated. Briquettes may have different shapes [8, 12-15].

A series of researches were conducted to investigate the use of coal slacks and paper wastes as the carbon-containing constituents. Thus an easy-to-produce and plain in composition fuel briquette can be made while at the same time coal and paper wastes are disposed of. Coal slacks increase the calorific value of the fuel briquette. Paper wastes play both binding and combustible role. The humidity of the initial mix comprises 8-10%. Briquettes were formed by extrusion method. The briquette has a horizontal perforation the cross-section of which is 25-40% of the briquette cross-section. Thus briquette combustion is improved. Cross-section less than 25% of the briquette cross-section reduces the combustion efficiency due to the lack of air. Cross-section more than 40% of the briquette cross-section does not improve the combustion efficiency but excessively increases the briquette volume (without increase in calorific value) and reduces the briquette strength. Briquette dimensions can vary significantly. Optimal content of coal slacks in the briquette is 30-60% and of paper wastes - 40-70%. If the coal slacks concentration is more than 60% the briquette strength is reduced and it becomes less inflammable. If the content of coal slacks is less than 30% and the content of paper wastes is more than 70% the calorific value of the fuel briquette is reduced. Mechanical strength of briquettes was determined based on the number of falls from 1.5 m height which the briquettes have withstood.

Paper-Coal Briquettes Test Results

Slacks, %	30	35	40	45	50	55	60
Paper wastes, %	70	65	60	55	50	45	40
Number of falls without substantial destruction	11	11	10	8	8	6	4

Also there were briquettes produced with a special incendiary layer (for example, containing nitrates), which is easily lighted from low-energy thermal sources (e.g. matches) and which then ignites the main part of the briquette. The briquettes were formed by an extruder with mixing and pressing zones. Dry nitrates were pressed into the main layer to the outer surface of the briquette by an additional pre-press screw. In the pressing zone the briquette is hardened and released from the extruder hard enough for its transporting to the drying unit. After drying the briquettes easily ignited, burnt steadily and were almost not evolving any fumes. Such briquette is very convenient in use. It is also possible to use both briquettes with incendiary layer and without it with approximate ratio of 1:10. In such a case the easily inflammable briquette with the incendiary layer ignites the briquettes without the incendiary layer. It is very cost efficient, as briquettes with the incendiary layer are more expensive than the briquettes without it [7, 10, 16, 17].

When the coal slams had high ash content, they were subjected to preliminary enrichment with the use of concentrating table [9] or special-design beneficiation hydrocyclone [11].

The wood processing is associated with large amounts of small by-products (chips, saw dust, collected dust, etc.). These are actual wastes. Such products are almost not used, they are harmful for the environment and create a fire hazard. The same situation is with the processing of slates. Both wood and slate wastes can be used as a source of energy. One of the processing methods for such wastes is briquetting.

Each year the scope of application of fuel briquettes and granules produced using the wood wastes gets broader. Waste disposal today is of the same importance for the producer as the product manufacturing. On the other hand, there is a problem of slate waste disposal. But briquettes made of only slate wastes have poor mechanical performance. That's why investigation of slate fines and wood wastes potential for briquetting and the use of produced briquettes as an alternative energy source is of high scientific and technical interest.

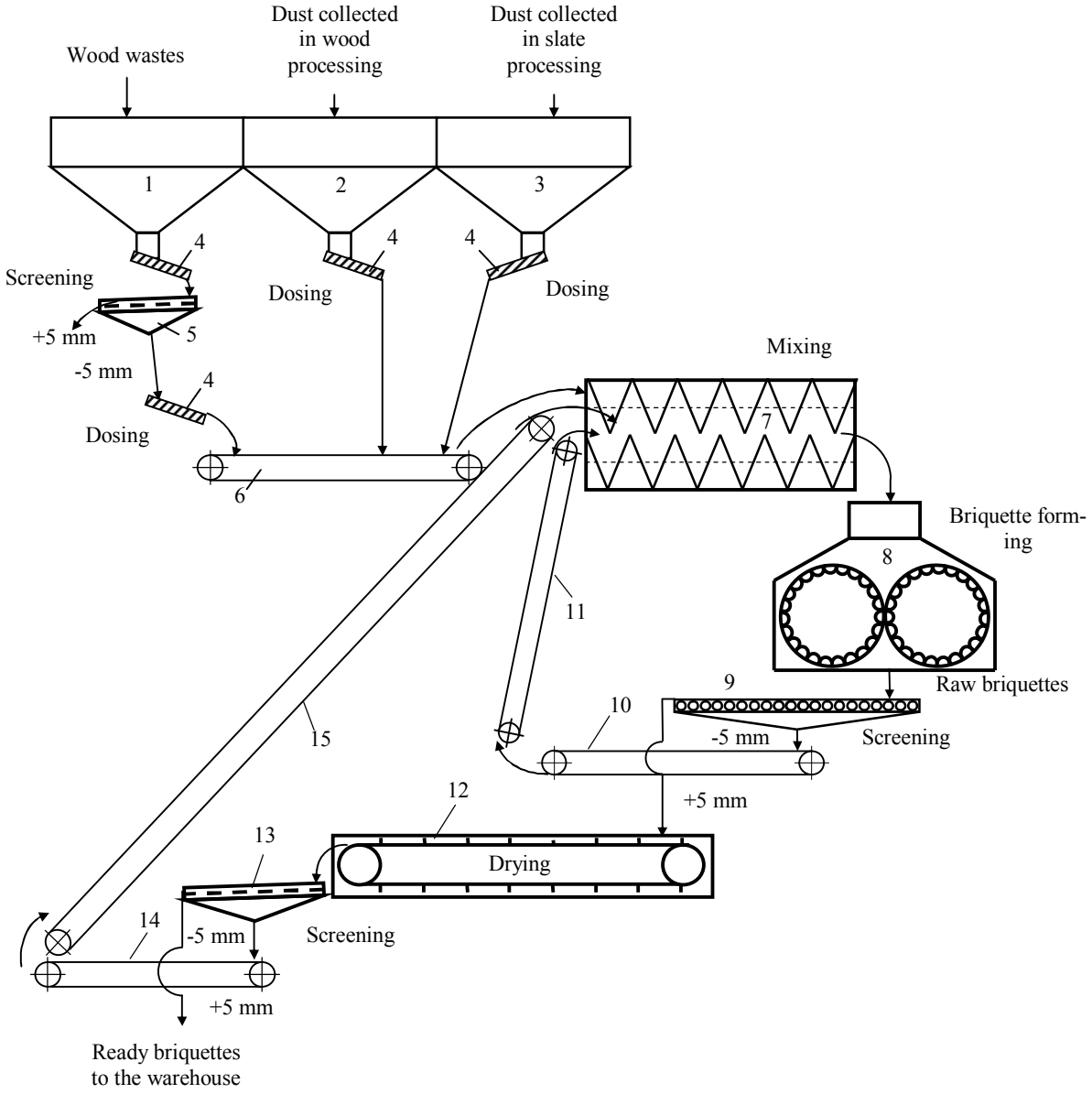
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A series of investigations were conducted to produce fuel briquettes from wood and slate industrial wastes [2, 5, 6].

As a core component of briquettes the wood wastes and dust collected in wood and slate processing were used in different proportions. Experimental studies have shown that optimal proportion of wood wastes, dust collected in wood and slate processing varies from 10:40:50 to 20:60:20.

If the content of wood processing by-products is less than 10%, their disposal is not efficient, and if it is over 20% the briquette's strength and calorific value is degraded. The content of dust collected in wood processing of less than 40% reduces the briquette strength and of over 60% deteriorates its calorific value without any gains in strength. The content of dust collected in slate processing of less than 20% reduces the briquette calorific value and of over 50% degrades the briquette strength.

As the base components for briquettes the wood wastes, dust collected in wood processing and in slate processing of Zavod Slantsy OJSC were used. Briquetting was performed without binding agents, as wood products have binding capacity. Thus production process was significantly simplified and made much cheaper. Briquetting process flow chart is shown in the figure.



Briquetting Process Flow Chart

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The raw materials for briquettes are loaded to the collecting bins 1, 2 and 3. From bin 1 the wood wastes by screw feeder 4 are conveyed to screening unit 5 where large grains (which can be used as household fuel) are separated from small particles which after dosing by screw feed doser are sent to the collecting conveyor 6. The dust collected in wood processing through screw feed doser is forwarded (simultaneously with dosing) to the collecting conveyor 6, the same happens with the dust collected in slate processing. On collecting conveyor 6 the base components are preliminary mixed for briquette production. Then these components move to mixer 7 for final mixing and to forming unit 8 where raw briquettes are shaped. After than raw briquettes are sent to screening unit 9. Briquettes with standard dimensions are further conveyed to drying unit 12, and irregular ones are returned to mixer 7. Dried briquettes after passing screening 13 are divided into small irregular ones which are returned by the conveyor system to the mixer 7 and the standard ones which are sent to the warehouse.

Briquettes were formed both by 'regular' pressing and by extrusion. Actual dimensions and shape of briquettes may significantly vary in response to the consumer's requirements.

Mechanical strength of briquettes was determined based on the number of falls from 1.5 m height which the briquettes have withstood. Test results are shown in the table.

Test Results for Wood-Slate Briquettes Produced by Pressing and Extrusion

Briquette composition			Number of falls without significant destruction
Wood wastes, %	Dust collected in wood processing, %	Dust collected in slate processing, %	
Pressing			
100	0	0	8
0	100	0	9
0	0	100	1
5	15	80	3
10	40	50	9
15	40	45	11
20	50	30	> 12
20	60	20	> 12
100	0	0	9
Extrusion			
0	100	0	9
0	0	100	1
5	15	80	4
10	40	50	10
15	40	45	12
20	50	30	> 12
20	60	20	> 12

Besides experiments were run when grain fraction of first stage of dust collection was preliminary removed from the dust collected in slate processing. Therewith additional enrichment took place, as large (grain) products contain much more non-organic components.

The produced briquettes were ignited just like regular woods, and evoked little smoke. They are much more compact then the regular woods, have high calorific value and burn longer. It means that the wood wastes and dust collected in wood processing and in slate processing can be used to produce full value energy sources while at the same time such wastes and dust are disposed of, partially addressing the environmental issues.

Conclusion. Thus technologies have been developed to produce fuel briquettes for household applications from various low-demand carbon-containing materials and wastes. To be specific, a technology was developed to produce household fuel briquettes with low ignition temperature lighted from low-energy thermal sources (e.g. matches). The briquettes are intended for household boilers, fireplaces, different ovens in order to cook food, heat residential and utility premises, cabins, etc. Production of such briquettes provides an additional source of thermal energy and a partial solution to environmental concern as the low-demand carbon-containing materials and wastes are disposed of.

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