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Obtaining small-sized heat-energy briquette of carbon-free flame

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Abstract

The article aims to develop a technology for producing a modern fuel briquette from rice husks(RH), which can be used in a complex, gives little flame, and does not emit toxic substances during combustion. The possibility of using such briquettes is used for heating and cooking on the street and unequipped places. Consumers of briquettes can be military units in combat operations or exercises, expeditions, and tourists working in areas where a stable fuel supply is complex. To this end, oxygen-rich components are adsorbed during thermal decomposition, using the sorption properties of activated carbon associated with an increase in its specific surface area, specific volume, and pores, including a solution of oxidants in an aqueous medium, which significantly increases the combustion rate of carbon-containing composite fuel.

Keywords: activated carbon, rice husk, adsorption, pores, fuel briquette, combustion, specific surface area.

1. Introduction

Currently, rice is grown in Kazakhstan in the valley of the Syrdarya River, Ili, and Karatal in the Kyzylorda, South Kazakhstan, and Almaty regions. Rice processing enterprises have accumulated as a result of processing rice grain. 20% of the waste is a large-tonnage agricultural waste [1]. Studies on creating highly efficient technologies for complex waste processing have shown that RH contain a large amount of carbon in the composition of natural polymers – cellulose and lignin. In addition to carbon, these polymers include a sufficient amount of hydrogen and oxygen, which, when decomposing organic compounds, contribute to forming activated carbon material with a developed porous structure [2]. RH fuel briquettes thermal value is close to coal's, and the ash content is six times lower, making fuel briquettes an environmentally friendly and promising fuel. Activated charcoal from RH can be obtained in two ways: by steam gas or chemical activation. Chemical activation has two main advantages over steam-gas activation: low activation temperature and high product yield [3]. Activated carbon is also obtained in a two-stage process combining chemical and gas-steam activation to get a product with the necessary quality and characteristics. The activation energy equals 279, 168, and 117 kJ/mol, respectively [4]. When using carbon dioxide, the activation temperature is maintained within 850-900 °C, water vapor – 650-700 °C, and oxygen – 350-450 °C.

A promising direction of RH processing is the simultaneous use of the mineral part (silicon) and the carbon-containing part. In these areas [5], research is being conducted to establish optimal ways to obtain silicon dioxide and activated carbon with different properties and characteristics. Activated carbon is the oldest adsorbent with a large surface area, controlled pore structure, thermal stability, and low acid-base reactivity. Activated carbon is a suitable material for removing various inorganic and organic [6, 7] substances dissolved in an aqueous medium or from the gas phase. Adsorption

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purification with activated carbon is recognized as an effective means of reducing the content of organic chemicals, chlorine, heavy metals, and liquid waste [8]. Popular sources of raw materials are used to produce activated carbon, such as coal [9], wood waste [10], coconut chips [11], and peat [12]. Despite its widespread use in the adsorption process, the biggest problem of using activated carbon on an industrial scale is its high cost and complexity in recovering adsorbents. In this regard, there is a need to search for new renewable and inexpensive materials as an alternative to adsorbents when solving problems of water pollution and waste gas utilization of various technological processes.

Theoretically, 409 kJ of thermal energy is released during the combustion of carbon.

$$C + O_2 = CO_2 + 97{,}8 \text{ kcal } (409.2 \text{ kJ})$$

In practice, when burning one kilogram of high-energy coal, 27 kJ of thermal energy is released, and when burning pure amorphous carbon, 34.1 kJ is released. The discrepancy with the theory is explained by the presence of mineral impurities and partial oxidation of coals. The choice of material for manufacturing briquettes is uniquely limited to amorphous carbon. Fuel briquettes with high energy value can be obtained by processing amorphous carbon obtained by carbonizing waste from processing plant raw materials.

The calorific value of fuel briquettes from RH is close to the calorific value of coal. At the same time, the ash content is six times lower, which makes fuel briquettes an environmentally friendly and promising fuel. Comparative characteristics of briquettes obtained from sawdust, RHs, and coal are given in the table 1 [13].

2. Experimental part

A porous carbonaceous material was obtained from the dried RH by the carbonization process under isothermal conditions. The carbonization process was carried out as follows: this usually occurs in an inert atmosphere (N_2/Ar) in the temperature range of 300-900 °C by pyrolysis. A carbonized rice shell containing carbon is obtained.

The 3H-2000PS1 automatic analyzer determines the specific surface area, specific volume, and pore size. The specific surface area was measured using the single-point and multi-point Brunauer-Emmett-Teller (BET) method and the Langmuir method for low-temperature adsorption of liquid nitrogen.

The elemental composition of the samples was determined by the method of energy dispersion spectroscopy on the device EDAX Ametek.

Table 1. Characteristics of briquettes from various raw materials

Characteristics	Sawdust	Rice husk	Coal
Density, g/м^3	1,1–1,26	1,0–1,2	1,2–1,5
Calorific value, kcal/kg	4000–4800	4800–5200	4400–5200
Ash content, % wt.	0,5–1,0	0,3–3,0	10–20

3. Results and their discussion

Without flame, heat-energy carbon material for research carbonized rice shell mechanical activation is crushed in a ball mill to 100 microns and connected to organic connectors in a vacuum extruder JC-70. A small-sized briquette is prepared, as shown in Fig. 1.

Activation of the small-sized briquette was carried out at a temperature of – 900 °C. With the use of carbon dioxide with an activation time of 20-120 min. As a result, Fig. 2 shows that the activated briquette sample has large ho-les and recesses at an increase of 100 microns. The elemental composition of the piece reflects 91.06% carbon (C) and 7.04% oxygen (O) of the material, as well as a small number of elements. It should be noted

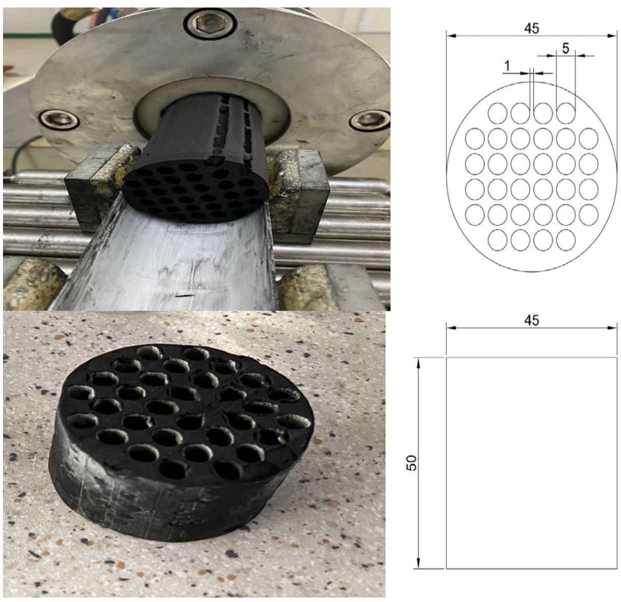
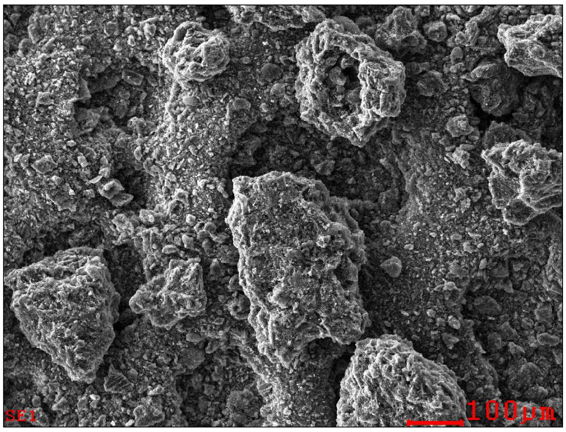
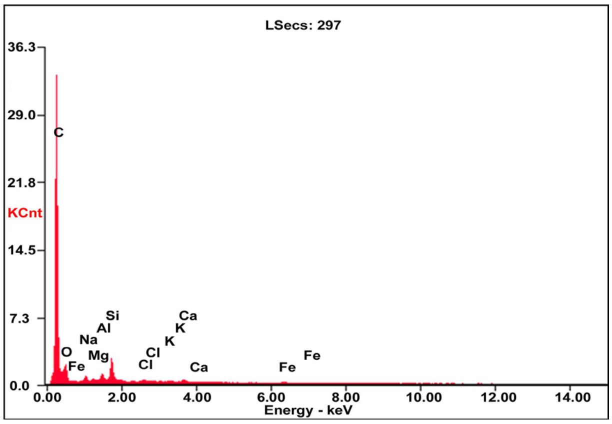


Fig. 1. Small-sized bicarbonate briquette: 50 mm, diameter: 45 mm.





Element	*Wt%*	*At%*
C	86.57	91.06
O	8.92	7.04
Na	0.64	0.35
Mg	0.13	0.07
Al	0.65	0.30
Si	1.75	0.79
Cl	0.29	0.10
K	0.22	0.07
Ca	0.34	0.11
Fe	0.49	0.11
Matrix	Correction	ZAF

Fig. 2. Analysis of SEM and EDAX of a heat-energy briquette of a carbon-free flame.

that other features indicate a connection with the cleaning technology.

The adsorption isotherm of activated briquette I linear and II logarithmic curves (Fig. 3), identified in the 3H-2000ps1 automatic analyzer, determined the specific surface area, specific volume, and pore size in the research laboratory of Plamya Research and Production Center LLP, show the microhardness of the adsorbent along with macro- and mesocosms according to the theory of polymolecular adsorption of Brunauer-Emmetter (BET) [14].

Based on studies [15, 16], activated carbon with a specific surface area of 514.54 m^2/g was obtained due to high-temperature activation of a carbon-free flame thermal energy briquette using carbon dioxide. Table 2 shows the development of the Brunauer-Emmett-Ter (BET) multipoint analysis.

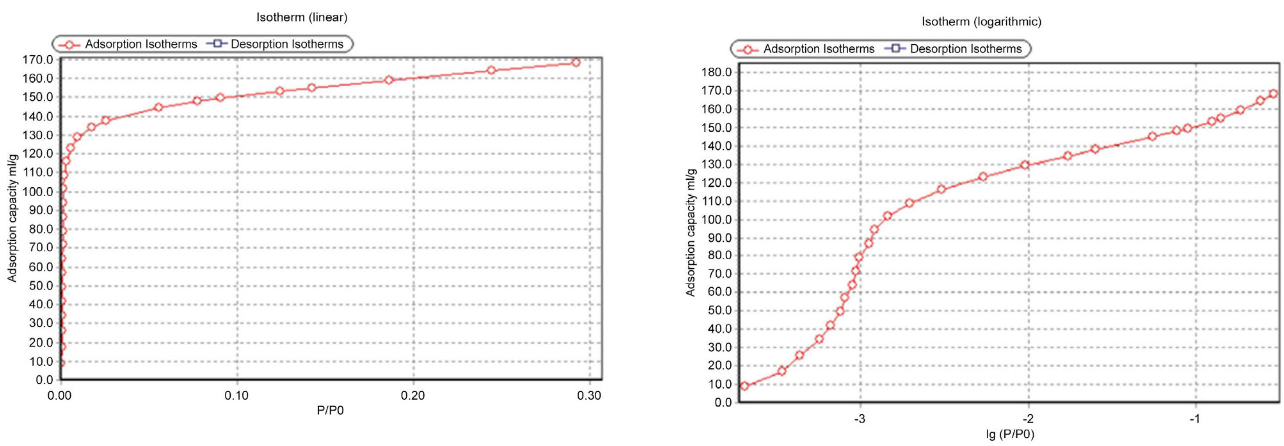


Fig. 3. Adsorption carbon-flame thermal energy briquette isotherm I linear and II logarithmic curves.

Table 2.Results of the multipoint analysis of the Bet carbon flame thermal energy briquette

BET Multi-Point Analysis Results			
Model:	3H-2000PS1	Tel:	8(727)2230121 LLP SPTC Zhalyn
BET Surface Area (P/P_0=0.0400-0.3200) 514.5412 m^2/g			

To date, there is a vast number of oxygen-containing oxidants. In this work, KNO_3 was used as an oxidizing component, which can release a large amount of oxygen during thermal decomposition [17]. To improve the combustion of carbon-free thermal energy briquettes in the process of adsorption of carbon materials in a vacuum medium in a solution of 5 g KNO_3 100 in water [18], we considered the combustion process using 36 g of activated carbon briquettes with a specific surface area of 514.54 m^2/g (Figs. 4-5).

A carbon-free fuel and energy briquette is a fuel capable, under certain conditions, of releasing energy in the form of heat due to chemical conversion. Carbon briquette is one of the widely known technological additives included in the composition of an energy substance to ensure energy intensity. For example, coal, which is a component of the earliest known chemical explosive, has been studied in detail for use as a modifier of the combustion rate of rocket fuel, chemical fuel. Combustion, a chemical fuel, is a chemical fuel.

After analyzing the results of burning a small-sized briquette in the open air (Fig. 5), we can find out that when the KNO_3 oxidizer is thermally decomposed, the carbonaceous material at a temperature of 105 °C completely burns in 2 min, a stable combustion, combustion indicator at a temperature above 462 °C in 59 min determines steady burning and high thermal value of carbonaceous material.

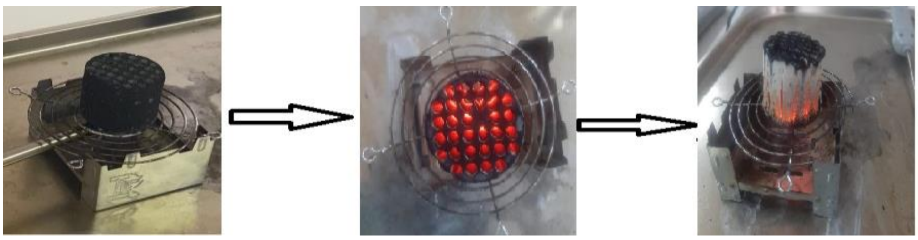


Fig. 4. Combustion of heat-energy briquette of carbon-free flame in the open air.

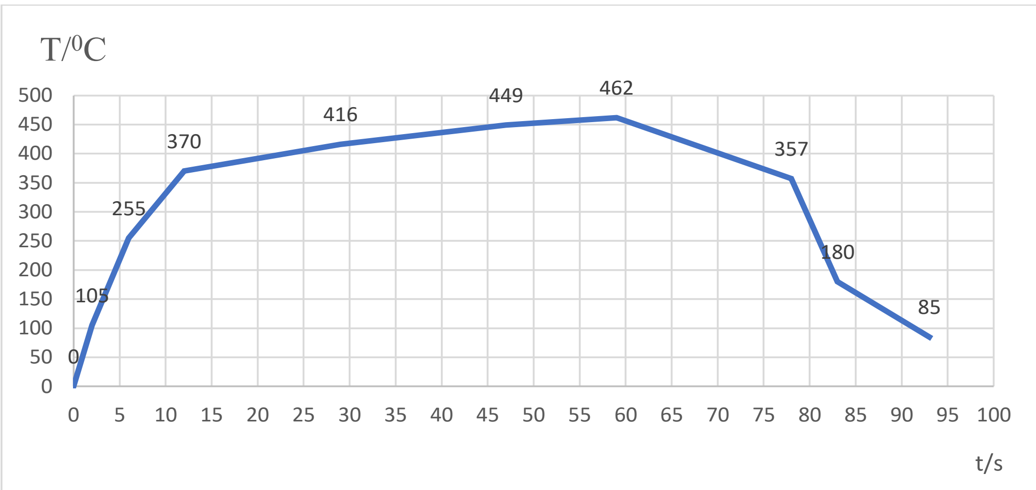


Fig. 5. The line of dependence of the time and temperature of combustion carbon flame heat-energy briquette in the open air.

4. Conclusion

The work consists of creating a heat-energy material of a carbon-free flame, which has specific chemical and physical properties that ensure stable combustion and high thermal value. The macro- and microstructure of the material, the morphology of the elements, and the shape and size of the pores determine the specific surface area and thermal conductivity. When developing material, the hierarchy of its composition and structural elements, the presence of chemical functional groups and morphological features, and the area and strength of the specific surface are designed. Carbon materials particularly limit the choice of material for making briquettes. By processing the carbon obtained from the carbonation of waste materials of production, it is possible to get fuel briquettes with high energy values.

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Получение безпламенных теплоэнергетических углеродных мелких брикетов

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Аннотация

Статья направлена на разработку технологии производства современного топливного брикета из рисовой шелухи, который может быть использован комплексно, дает мало пламени и не выделяет токсичных веществ при горении. Возможность использования таких брикетов используется для обогрева и приготовления пищи на улице и в не оборудованных местах. Потребителями брикетов могут быть: воинские части в условиях боевых действий или учений, экспедиции и туристы, работающие в районах, где стабильное снабжение топливом затруднено. С этой целью, используя сорбционные свойства активированного угля, связанные с увеличением его удельной поверхности, удельного объема и пор, адсорбируют богатые кислородом компоненты при термическом разложении, включая раствор

окислителей в водной среде, что значительно повышает скорость горения углеродсодержащего композитного топлива.
Ключевые слова: активированный уголь, рисовая шелуха, адсорбция, поры, топливные брикеты, горение, удельная поверхность.

Көміртекті жалынсыз жылу-энергетикалықшағын өлшемді брикет алу

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Аңдатпа

Мақалада кешенді түрде қолдануға болатын, аз жалын беретін және жану кезінде улы заттар шығармайтын заманауи отын брикетін күріш қауызынан өндіру технологиясын жасауға бағытталған. Мұндай брикеттерді пайдалану мүмкіндігі далада және жабдықталмаған жерлерде жылынуға және тамақ өнімдерін пісіруге қолданылады. Брикеттерді тұтынушылар: ұрыс қимылдары немесе оқу-жаттығулар жағдайындағы әскери бөлімдер, тұрақты отынмен қамтамасыз ету қиын аудандарда жұмыс істейтін экспедициялар және туристер болуы мүмкін. Осы мақсатта белсендірілген көмірдің меншікті бетінің, меншікті көлемінің және кеуектерінің ұлғаюына байланысты сорбциялық қасиеттерін пайдаланып, сулы ортада тотықтырғыштардың ертіндісін қосқанда термиялық ыдырау кезінде оттегіне бай компоненттерді адсорбциялап көміртектті композиттік отынның жану жылдамдығын айтарлықтай жоғарылатады.
Кілт сөздер: белсендірілген көміртек, күріш қауызы, адсорбция, кеуектер , отын брикеті, жану , меншікті бет ауданды.