Experimental estimation of specific heat of combustion of agglomerated peat fuel

A A Kokonkov, D D Lyah, S L Ivanov, G A Stroykov and P V Ivanova
Saint-Petersburg Mining University, 2, 21st Line V. O., St. Petersburg, 199106, Russia
E-mail: kokonkov.aa@yandex.ru

Abstract. Nowadays, the development of remote regions of Russia related to energy security is increasingly relevant. Existing production technologies have a significant anthropogenic impact on the environment. To reduce the negative consequences of this impact, it is necessary to develop complexes of mining equipment capable of complex processing of excavated peat-wood raw materials and prepare them for further operations on the production of finished products. The article describes a chipping machine for preparing peat-wood mix for molding into briquettes. A description of the experiment on the calorimetric installation of the company IKA model C200, based on the estimation of the calorific value of agglomerated fuel from peat-wood raw materials, is given. It is shown that peat briquettes do not significantly differ in their calorific value from peat briquettes, and at the same time, they have greater strength compared to the latter.

1. Introduction
Russian Federation has the largest deposits of peat of relative humidity, which exceeds the energy reserves of hydrocarbons, coal, oil shale, and the country, while the natural increase in peat in the country is \( \times 10^6 \) tons. The widespread use of peat raw materials in the regional energy sector, as an alternative to hydrocarbons, is aimed at diversifying the country's fuel balance, increasing its energy security, and reliability of energy generation based on local fuel, especially for decentralized energy supply areas of remote and inaccessible areas with imported energy resources.

One of the main obstacles to using local peat fuel as the main one is the cost and high risks of environmental damage when implementing existing production technologies, which are associated with the preparation of peat deposits for operation for the development and use of standard mining equipment. An innovative approach to providing territories with local peat fuel boils down to the use of climate-saving technologies in the extraction, without water reduction, and the integrated use of the extracted peat raw materials. However, such an approach is impossible without the creation of innovative complexes and modules of mining equipment for quarrying peat raw materials, capable of wasteless processing the entire volume of extracted peat-wood raw materials into a marketable product without violating the fragile ecological balance of the developed irrigated areas [1–5].

2. Materials and methods
The realization of this task requires the development of specialized mining equipment, which allows separating peat and wood raw materials, turn waste into a marketable product, achieving stability of parameters of processed excavated raw materials from irrigated deposits [6–9]. In the complex and non-waste processing of peat raw materials, followed by obtaining a high-quality commercial product, it is
necessary to take into account many basic properties that affect its quality, and such machines must have high reliability [10]. Of most significant importance in this regard are the physicomechanical properties of peat raw materials: density, humidity, and friction coefficients. For the complex processing of peat and wood raw materials, it is necessary to use a chopper capable of grinding excavated raw materials [5, 11, 12].

One of these machines is a disk chipper (Fig. 1) whose working body is the disk that is most suitable for chopping round trunks and felled trees (Fig. 2 a). As a result, it is possible to obtain medium-sized chips with high quality. The working body of these machines is made in the form of a flat (Fig. 2 b) or profile (helicoidal) (Fig. 2 c) rotating disk 2 in the vertical plane equipped with knives 1. The helicoidal working surface of the disk, which is helical, is located between the knives. The helical surfaces merge with the trailing edges of the knives, sharpened along the same helical lines. When rotating such a disk with knives located in it and while feeding material to the disk, the knives cut the wood not in the same plane as in machines with a flat disk, but along a helix. Cutting occurs not along the vertical plane, but the screw. These features of cutting ensure a stable position and self-tightening of the processed wood during the cutting process.

![Disc chipper diagram](image)

**Figure 1.** Disc chipper: 1 – frame; 2 – loading cartridge; 3 – casing; 4 – rotor; 5 – brake; 6 – electric motor

Wood is cut along the fibers at an angle and is carried out between the knives mounted on the disk. The diameter of the knife disc, depending on the performance of the machine and the cross-section of the chopped timber, is from 0.3 to 3 m, the angular frequency is from 16 to 52 Hz, the number of knives on the disc is from 2 to 16. The angle of knife sharpening is usually in the range from 30 to 45°. Disc chippers are produced with the inclined and horizontal feed of processed raw materials. In machines with an inclined feed, the loading door is located at an angle of 45–50° to the direction of the fibers, resulting in significantly reduced energy consumption for wood chopping. In grinders with horizontal feed, the cartridge is installed at an angle of 38° to the plane of the disk of the machine. As a result, the cutting conditions are facilitated, and the energy consumption is reduced. The size of the chips is determined by the size of the protrusion of the knives on the disk, which can be adjusted within specified limits.

It is necessary to assess the amount of energy released when burning a peat-wood mixture with specified characteristics for determining the effective and integrated using of peat-wood raw materials with their subsequent formation into energy-dense fuel with reinforcement of wood shavings.
To prepare for the experiment, 4 samples of various compositions were prepared: 1) sample 1 – peat raw materials of natural moisture content with the addition of 3 % pre-dried wood inclusions from the fallow, of the briquette volume; 2) sample 2 – peat raw materials with the addition of 3 % wood inclusions from deposits of natural moisture content, from the volume of the briquette; 3) sample 3 – peat raw materials of natural moisture content with the addition of 3 % marketable wood, from the volume of the briquette; 4) sample 4 – peat raw materials of natural moisture content, without additional inclusions. Peat raw materials used in the formation of briquettes were with the following characteristics:

- Type of peat raw materials: lowland;
- Ash content not more than 10 %;
- Degree of decomposition no more than 20 %;
- Mass fraction of moisture no more than 60 %.

![Figure 2. Scheme of wood cutting in disk chippers: a – general scheme; b – a diagram of the interaction of chopped wood with a flat disk; c – a diagram of the interaction of chopped wood with a helicoidal disk; 1 – knife; 2 – knife disc; 3 – shredded material; 4 – casing; 5 – loading cartridge; 6 – slot foot; 7 – counter-knife](image)

3. Experimental investigation

During preparation for the experiment, four groups of briquettes with the characteristics declared for each of the samples were prepared and formed. The briquettes were formed on a Zwick / Roell Z100 universal testing machine. The moisture content of the briquettes was 9–10 %. The diameter of each briquette was 100 mm and the thickness 35 mm. As a result of the formation of the samples, the wood chips reinforced the formed briquette.

Estimation of the specific heat release during the combustion of peat briquettes is based on using of the IKA model C200 calorimeter (Fig. 3). Before the experiment, calibration was performed by burning tablets of certified benzoic acid with a known calorific value. The amount of heat required to raise the temperature of the calorimeter by 1ºK is used to determine the heat capacity of the system.
Figure 3. IKA calorimeter model C200

This value is used for the subsequent determination of the calorific value. The material for the experiment was taken from each of the samples of 100 g and ground to a powder state. Before the experiment, the moisture content of each of the samples was measured (Table 1).

Table 1. Moisture content in samples, %

| Sample № | Moisture content, % |
|----------|---------------------|
| 1        | 9.85                |
| 2        | 9.18                |
| 3        | 9.60                |
| 4        | 9.75                |

Preparation of a vessel for decomposition requires a sequence of specific actions:
- Unscrew the screw cap and remove the cover;
- Fasten the cotton thread in the form of a loop in the center of the ignition wire;
- Weigh sample material with an accuracy of 0.1 mg and place in a crucible. Also, distilled water or a ready-made solution must be added to the decomposition vessel.
- Close the decomposition vessel. Place the cover on the housing and press until the cover comes into contact with the stopper.
- Close the decomposition vessel.
- The decomposition vessel can be installed in the measuring cell.

Figure 4. The composition of the vessel for decomposition

After preparing the vessel for decomposition, the underlying operating mode was selected on the calorimeter. In the dialog box, the sample parameters are entered: weight; by default, a correction is set for the calorific value of the cotton thread as a means of ignition of 50 J. The decomposition vessel is installed in the calorimeter and closed. The decomposition vessel is filled with oxygen (about 60 seconds). Then the temperature of the outer vessel is stabilized (90-120 seconds), and the inner vessel is filled with water. The monitor displays a graph of temperature changes (Fig. 5).
At the end of the measurement, the lid of the measuring cell opens, the pressure in the decomposition vessel is vented. At the same time, the inner vessel is emptied. After that, the cell cover opens completely. Using the software installed on the computer, the energy of the amount of heat released during the combustion of the samples was determined (Fig. 6). The specific calorific value of peat briquette briquettes is comparable with the corresponding energy indices of brown coal briquettes and coal from the Donetsk basin.

4. Conclusion
It was revealed that a sample consisting of peat raw materials without additional inclusions has the highest calorific value compared to other samples. In this case, a sample of peat raw materials with marketable wood has a calorific value of 3% less than purely peat. Thus, when logging, which is produced during the development of peat deposits, wood chips can be added to briquette fuel. The addition of wood chips allows reinforcing the briquettes, which leads to an increase in their strength and minimize the risks of cracking. Samples containing wood from peat deposits had a calorific value lower than that of a sample from peat raw materials by 4.5-5%. This fact demonstrates that the wood located
in the fallow is also suitable for use in addition to briquette fuel. Such an additive will not only contribute to the reinforcement of the briquette and exclude the formation of wood dumps. Such complex application will contribute to the development of peat production and increase the environmental situation, due to a waste-free system for the extraction of peat raw materials.

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