SELECTION OF PARAMETERS OF TECHNOLOGICAL EQUIPMENT FOR THE EXTRACTION COMPLEX OF RAW PEAT MATERIALS FROM UNDRAINED DEPOSITS

Irina Khudiakova, Sergey Ivanov

Saint Petersburg Mining University, 199106 Saint Petersburg; irikhudyakova@yandex.ru; lisa_lisa74@mail.ru

ABSTRACT. Expanding the use of peat is strategically aimed at diversifying the country's fuel balance, improving the reliability of energy supply and its energy security. The greatest impact is seen in decentralised energy supply zones, remote and inaccessible areas of the country.
A technology of extraction and quarry processing of raw peat materials without preliminary preparation of the field within the framework of environmental technologies and the selection of the scheme solution of the complex of mining equipment for its implementation are proposed.
The paper presents the operational energy consumption for the schemes of technological mining equipment floating complex for the extraction and processing of raw peat materials. The general structural formula of the complex is given. An algorithm for selecting the main parameters of the complex equipment for the extraction and processing of peat raw materials from an undrained deposit is proposed.

Keywords: raw peat materials, structural scheme, the structural formula, the complex of mining equipment, energy supply

ИЗБОР НА ПАРАМЕТРИ НА ТЕХНОЛОГИЧНО ОБОРУДВАНЕ ЗА КОМПЛЕКС ЗА ДОБИВ НА ТОРФЕНА СУРОВИНА ОТ НЕДРЕНИРАНИ НАХОДИЩА

Ирина Худякова, Сергей Иванов
Санктпетербургски минен университет, 199106 Санкт Петербург

РЕЗЮМЕ. Разширяването на използването на торфа има стратегическо значение за диверсификация на източниците на енергия, подобряване на надеждността на енергийните доставки и енергийната сигурност на страната. Най-голям ефект от този процес се наблюдава в отдалечените и недостъпни райони с децентрализирано електрозахранване.
Предложена е технология за добив и обработка на торфената суровина, без предварителна подготовка на находища, съобразена с изискванията за опазване на околната среда. Предложени са схемно решение на комплекса и необходимото за реализацията му минно оборудване.
В работата са представени оперативните разходите за енергия при различни схеми на технологично минно оборудване на плаващ комплекс за добив и преработка на торфената суровини. Дадена е обща структурна формула на комплекса. Предложен е алгоритъм за избор на основните параметри на цялостно оборудване за добив и преработка на торфената суровина от недренирани находища.

Ключови думи: торфена суровина, структурна схема, структурна формула, комплекс на минно оборудване, електрозахранване

Introduction

At present, the need for extraction of raw peat materials is due to the production of cheap local fuel, agricultural fertilizers to increase soil fertility and to promote the implementation of import substitution programmes in solving the problems of increasing energy, as well as reducing the risks of fires in the waste areas of peat deposits, especially if they are accompanied by preliminary dewatering of territories.

The use of traditional fuels leads to the emission of a large number of toxic substances into the atmosphere and intensifies the processes leading to climate change. Extraction and use of these relatively non-renewable minerals is quite expensive. Many countries, in order to save, use renewable local energy sources, which pollute the environment less. In addition, they do not require large costs for their production, processing and delivery. These resources include peat, and peat raw materials are used as a fuel. For example, in Germany, the Republic of Finland, the Kingdom of Sweden, the Republic of Ireland, the share of fuel derived from peat raw materials accounts for up to 10 % of energy production.

In Russia, this energy source is underestimated, and its share in the country's energy balance is only 0.2%. Meanwhile, there are large peat deposits in 29 regions of the Russian Federation, in fifteen regions the share of peat exceeds 60% of the total potential of renewable energy sources. The total peat reserves are slightly less than $70 \cdot 10^9$ tons of conventional fuel and exceed the energy potential of domestic hydrocarbon reserves. Each year, the peat in Russia is growing by $200 \cdot 10^6$ tons conditional humidity. At the same time, the expansion of peat use is strategically aimed at expanding and reducing the cost of the resource base, diversifying the country's fuel balance in order to increase both the reliability of energy supply and competition in the supply of energy resources, reducing CO_2 emissions and improving the country's energy security.

Analysis of the use of peat raw materials and environmental technologies

Peat is widely used as a fuel in the form of crumbs in thermal power plants, energy-dense fuel in the form of pellets, briquettes and pieces for heating. The cost of heat production from peat briquettes is lower in relation to coal by 17 %, and to fuel oil - by 45 %. In the pyrolysis of peat, a generator gas is produced, which is used as a fuel in both electric power generation and heat power engineering of enterprises. In agriculture, peat raw materials are widely used as fertilizers, for the production of seedlings, composting and substrates. In the chemical industry it is a valuable raw material in the production of ammonium salts, ammonia, wax, fatty acids, oils, paraffins, polymers, alcohols, dry ice, peat-alkaline reagents. Due to its high moisture capacity, heat capacity and adsorption properties, peat raw materials are widely used in medicine as anti-inflammatory and tonic agents, as well as for the manufacture of gels, balms, extracts, filter materials and sorbents for the absorption and fixation of oil spills and oil products, absorption of oils, fuel oils, gasoline, cleaning contaminated surfaces of water and areas of industrial facilities, equipment. Peat is widely used in reclamation of disturbed lands, elimination of landfills and landfills. Peat raw materials are widely used in construction in the form of peat insulation boards, panels, building blocks, concrete additives, components of various coatings, green construction.

When assessing the possibility of developing peat deposits, it is necessary to take into account that they are important elements in the chain of interrelated and interacting components of the natural environment and any anthropogenic impact causes its change.

Within the framework of environmental technologies and environmental management, the authors proposed the technology of extraction and quarry processing of peat raw materials without preliminary preparation of adeposit, excluding hydraulic engineering measures for drainage of adeposit and preparation of production sites, surface layers and production areas (patents RU №2599117, № 2655235, № 2672366).

In the extraction of peat raw materials complexes of mining equipment on the basis of floating platforms it is expected to carry out the production process, both from the surface and from the water. The use of traditional methods of excavation is very effective at depths of up to 4-5 meters. In this case, it is necessary to use modernised equipment that does not allow the erosion of peat raw materials separated from the massif from the working body of the excavating mining machine, or the use of a continuous process of creating a hydro pulp with its delivery to the floating platform by hydro-transport and subsequent centrifugation or extraction of excess moisture, which is more costly than conventional excavation.

The rationale for the choice of an effective structure of complex

The complex of mining equipment is a self-propelled floating platform with mining equipment placed on it and means of autonomous power generation.

Depending on the final commodity product, different circuit solutions of the complex are possible, and its functional structure includes the following blocks: production; separation and crushing of peat-wood raw materials; moulding; drying; production of a commodity product.

The advantages of the proposed technology implemented in the framework of environmental management are presented in Table 1.

Table 1. *Comparison of milling and proposed technologies for the same production volumes*

Milling technology	Proposed technology
Cut depth 0.25 m	Excavation depth 2-5 m
Density of peat raw material γ= 500 kg/m3	Density of peat raw material γ= 1040 kg/m3
The area of the production site and its rent per year – 1.0/1.0	The area of the production site and its rent per year – 0.05/0.05
The term of preparation of the field – 3 years	The term of preparation of the Deposit — not required
Range of mining machines for preparing the field: summary of the forests; drainage of fields; preparation of field;	Range of mining machinery for the preparation of the deposit – not required
The technological complex of machinery for processing of peat raw materials and energy is missing	The technological complex of machinery for processing of peat raw materials and energy is provided
Complex machines for the preparation and repair of areas is provided	Complex machines for the preparation and repair of areas – not required
Environmental risks (dust, fires, emissions from internal combustion engines of vehicles, dewatering, destruction of forests and ecosystems)	"Wet technology" – no risk of fire, no dusting, minimised wastage
Reclamation of mined-out areas	No remediation is required. Artificial pond in the framework of environmental technologies.
Seasonality of production and dependence on weather conditions	Production is carried out year-round. Reduced dependence on weather conditions

As can be seen from the table, the use of a floating complex in comparison with the milling method of production will reduce production costs, the timing of a deposit, the range of equipment, their transport component, reduce the risks of man-made disasters, get away from the seasonality of production.

At the same time, it is the primary choice of equipment that determines the entire technological chain of the mining machines of the complex. Figure 1 shows four variants of circuit solutions for the implementation of the complex.

The main mining equipment in the block of extraction of peat raw materials can be: a manipulator with a bucket (reverse shovel); a multi-bucket chain excavator, a vertical screw-cutter; mechanical and hydraulic production.

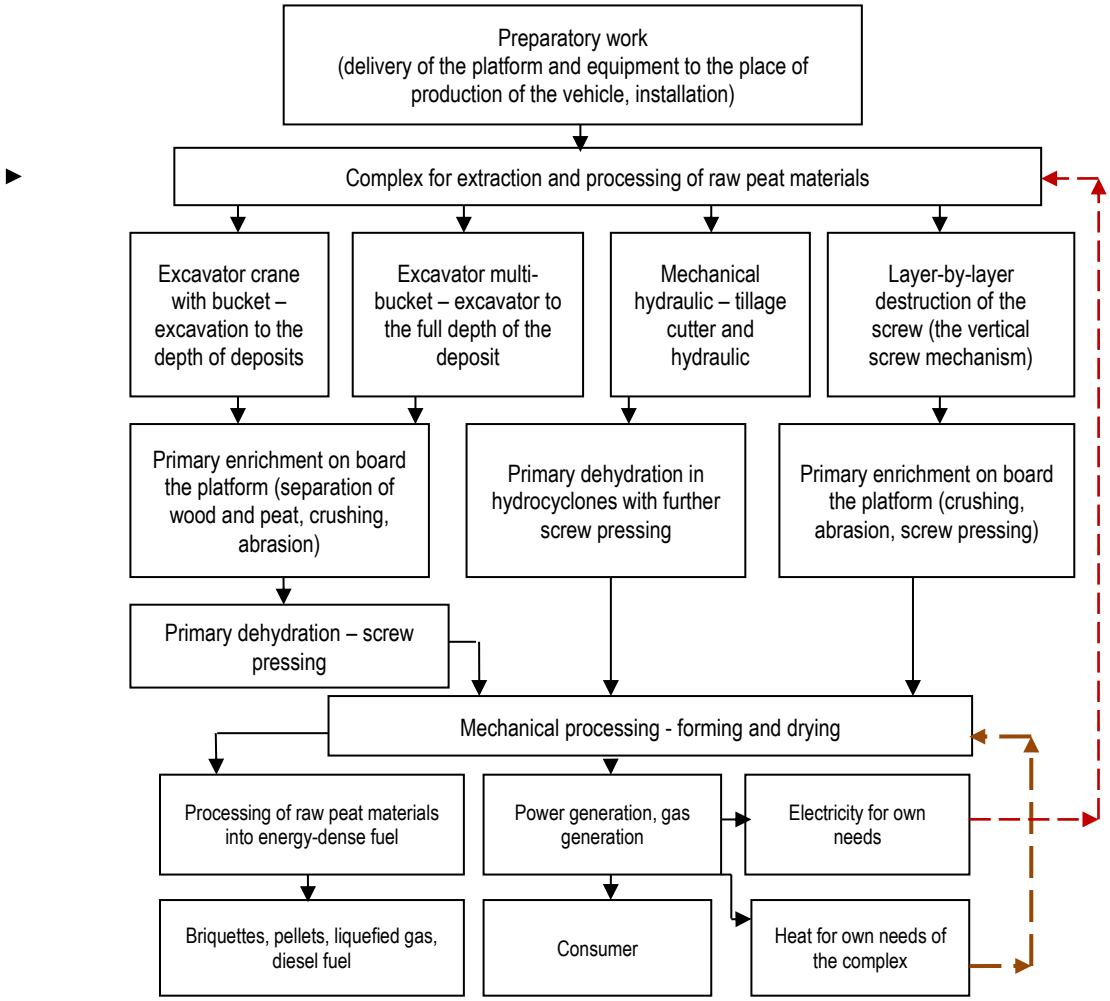

Fig.1. Scheme solutions for extraction and processing of peat raw materials

Depending on the adopted technology of extraction of raw peat materials, further primary enrichment and dehydration are carried out, followed by mechanical treatment on board the complex and generation of thermal and electrical energy.

For each scheme, energy costs were calculated both for the preparation of the field and for the production of 50 thousand tons of peat per year of 45% humidity in the development of a conventional peat deposit. The degree of decomposition of peat was 32%, the stump-1.5, the life of the field – 10 years. The results of calculations are summarised in Table. 2. At the same time, the total energy consumption per 1 ton of 45% moisture of the extracted raw peat materials with the basic milling technology was 8.31 MJ/T45%.

As can be seen from Table 2, the specific energy consumption in the implementation of any of the four circuit solutions of the complex with the installation of existing equipment sizes is lower in comparison with the milling technology of peat extraction. At the same time, the fourth chain of technological mining equipment is the most energy-consuming, the specific energy intensity of which is only 10% lower than the basic one. The least energy-consuming is a chain with a single-bucket excavator, or rather a manipulator. The specific energy consumption in this process chain is 21% lower than the basic one. At the same time, specially designed mining machines for a specific set of equipment can give even greater energy savings to the entire chain of technological mining machines. In any case, the specific energy consumption for the production of a ton of peat products will be lower than in the milling method of production.

Table 2. *Total energy consumption for the schemes of technological mining equipment of the complex for the extraction and processing of peat raw materials with a capacity of 50,000 $T_{45\%}$*

№	Specific energy consumption, MJ/$T_{45\%}$
Scheme I «Manipulator with a bucket»	6.52
Scheme II with «multi-Bucket excavator»	7.0
Scheme III «Mechanical hydraulic method»	7.29
Scheme IV «Using the auger-cutter»	7.47

Having established the fundamental benefits of implementation of environmental technologies for the extraction of raw peat from the flooded deposits with the use of a floating complex, it is necessary to develop theoretical approaches to the evaluation of the energy consumption of

the complex, equipped with any set of mining equipment and to provide an opportunity to analyse the structure of such a complex with a unified voice. To do this, we will make a general structural formula of the complex of peat extraction and processing (CPEP) (1):

$$CPEP^{n}=\Sigma\{PB[\Sigma(\Sigma((((M_i+Fg_j)+Fe_j)+I_i\cdot E_i)_i))_j] + SB[\Sigma(\Sigma(((M_i+Fe_j)+I_i\cdot E_i)_i))_j] + MDB[\Sigma(\Sigma((((M_i+F(e)g)_i+Fe_j)+I_i\cdot E_i)_i))_j] + CoB[\Sigma(\Sigma(((M_i+Fe_i)+I_i\cdot E_i)_i))_j] + DrB[\Sigma(\Sigma((((M_i+Fg_i)+Fe_j)+I_i\cdot E_i)_i))_j] + 5TrB[\Sigma(\Sigma(((M_i+Fe_i)+I_i\cdot E_i)_i))_j] + EPB[\Sigma(\Sigma((((Ge_i+M_i)+Fe_j)+I_i\cdot E_i)_i))_j]\} + I\cdot E \quad (1)$$

In the general case, the complex of mining equipment can be represented by the following blocks: production (DB)=PB, separation (SB), mechanical dewatering (MDB), drying (DrB), commercial products (CoB), power generation (EPB), transportation (TrB), united into a single chain by means of links providing for: only the harmonisation of the (-) connection (+) or the combination (•). In this case, by changing the parameters of each individual machine, module, unit, one can analyse the performance and optimise the parameters of the whole complex and its components.

Taking into account that a single complex of equipment on a floating platform for the extraction and processing of peat raw materials requires significant areas, it is advisable to leave only a complex of mining equipment for extraction, separation and primary dehydration on the floating platform, and to concentrate the bulk of the equipment for processing and energy generation on the shore, delivering primary dehydrated peat raw materials by floating shuttle containers operating in the shuttle mode, which will contribute to improving the efficiency of the entire complex.

Conclusions

The study found that the use of floating complex mining equipment for the extraction and processing of raw peat materials from the undrained deposits in modern conditions is more effective than the extraction of milling peat, while such complexes successfully fit into environmental technologies and, contributing to the development of energy potential of remote areas of the country, increase its energy security.

Within the framework of the study, a number of circuit solutions are proposed that determine the structure and composition of floating complexes for the extraction and processing of raw peat materials, and a complex of mining equipment in its composition is determined.

The algorithm of the choice of parameters of the mining equipment of a complex is offered, its realization in electronic model allows a simulating process of career processing of peat raw materials, providing the maximum efficiency of joint work of the equipment.

References

Grevtsev, N. – In: A. G. Samarov. 2009. System principles of choice of technology for extraction and processing of peat and man-made materials. News of universities. *Mining Journal, 8,* 14–20.

Kashinskaya, T. Ya., A. P. Gavrilchik, I. V. Ageychik. 2011. On the choice of environmentally compatible technologies for the development of peat deposits. – *Nature management,* 19, 144–149.

Khudyakoval, N. et al. 2017. The formation of the structure of the main technological equipment of the autonomous complex for the extraction of peat from undrained deposits. – *Internet-journal "Science of Science", 9*, 3.

Mikhailov, A. V., S. L. Ivanov, V. V. Gabov. 2015. Formation and effective use of the machine park of peat mining companies. Vestnikpnipu. Geology. Oil and gas and mining. Perm. 14, 82–91.

Rodionov, V. Z. 2017. Development of peat deposits in the Leningrad region (problems and solutions). – *Regional ecology*, 3(49), 59–64.

Shtin, S. M. 2011. Application of peat as fuel for small power engineering. – *Mining industry*, 7, 82–96.

Timofeeva, S. S., G. R. Mingaleeva. 2014. Prospects of peat use in regional power engineering. – *Proceedings of Tomsk Polytechnic University. Equipment and technologies in the energy sector, 325,* 4, 46–55.

Titova, G. D. 2016. The Concept of ecological debt: development and possible applications in practice. *Regional ecology,* 1(43), 7–14.

Vagapova, E. A., S. L. Ivanov, I. N. Khudyakova. 2017. Assessment of energy consumption of technological equipment of an Autonomous modular complex for extraction and processing of peat raw materials from an untreated field. – *Socio-economic and environmental problems of mining, construction and energy: 13th international conference on mining, construction and energy. In 2 t. T. 1: the proceedings of the conference*. Izd-voTulgu, Tula, 156–163.