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Arranging mining machinery systems in a single classification by the types of raw peat being extracted

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Abstract. The following article presents a single classification of peat extraction strategies, methods, mining machinery systems, and types of raw peat. It also defines types of connection established between blocks, modules and mining machines within an extraction system. We suggest nine main mining systems that include specialized blocks and modules. Given strategies (peat quarrying and surface layer extraction) utilize the following techniques – excavation, hydraulic extraction, loosening and auxiliary operations. Techniques of peat extraction are further divided into methods. Extraction techniques imply the division of structure of peat materials into five groups – cloddy, sod, and milled peat, slurry and secondary raw materials. It was the parameter of peat material structure that made it possible to link extraction methods with tools used for their realization. Systems of mining machinery were classified by the types of connection between blocks and modules – coordination, connection, and coupling. The next level of our classification includes functions of mining systems (extraction and processing, deposit preparation, drainage, extraction, recultivation, deposit maintenance, subordinate and auxiliary systems, and systems for product transportation). Blocks and modules linked by coordination, connection, and coupling form a mining system that is used within the whole process of peat extraction.

1. Introduction

Peat sees its wide use in energy and agriculture sectors, and, moreover, it bears fairly high significance for environmental conservation. As a renewable energy resource, peat is regarded to be an alternative for fossil fuels. Peat combustion does not release sulphur oxide in the atmosphere, thus, making it safer for the environment. Additionally, burning of peat leaves almost no waste, as peat ash finds its use as a fertilizer [1]. Traditional peat harvesting requires dewatering, while surface layer method relies on enormous production areas causing environmental damage; all that urges the development of new peat extraction technologies that will have a marginal impact on climate change [2].

2. Background of the issue

Efforts to classify the methods of peat extraction and machinery, necessary for that, were independently made multiple times [3–8]. It seems reasonable to combine all available data about methods and machinery in a single classification. These two systems, though may seem akin but still stay quite different, can be harmonically combined only if categorization based on the types of raw peat is introduced [3]. If such classification shows high informational capacity, it could become a roadmap that would specify an area for development of modern mining machinery with regard to the current level of technologies.

Modern conditions of peat extracting and processing set new requirements for mining equipment and machinery. Today's production benefits from systems of highly efficient machines strictly interconnected under a single command of their transfer functions with precisely adjusted functional links within material and power flows integrated into a single system [5, 7]. For that reason, this new classification must provide information for designing conceptually new mining equipment to operate in conditions of peat deposits in Russia.

3. Peat winning methods

All peat winning techniques can be divided on the basis of two strategies: peat quarrying and surface layer production (Figure 1). These two strategies encompass three main techniques of peat winning: excavation, loosening, hydraulic extraction, and auxiliary operations.

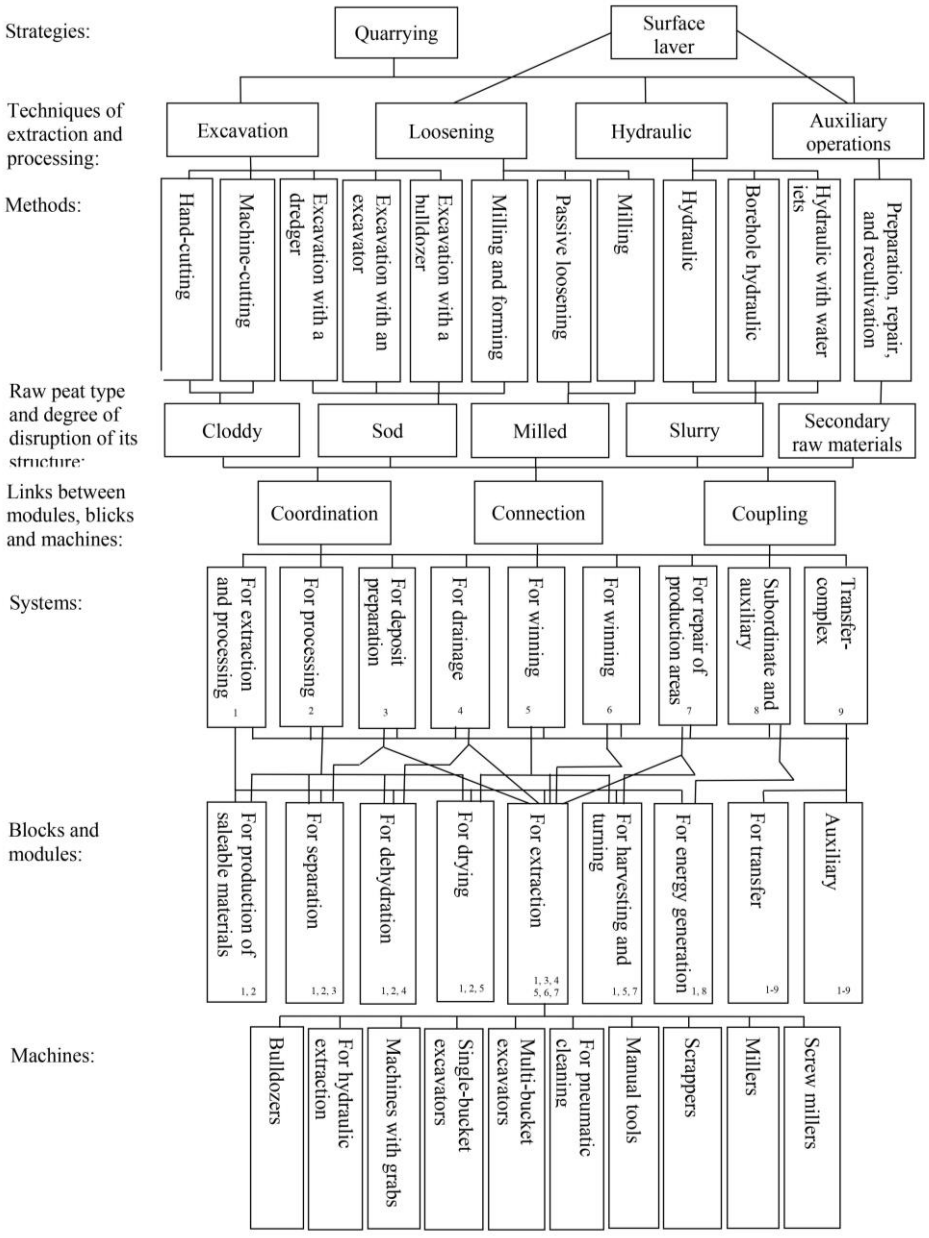

Figure 1. Classification of mining technologies and systems for the extraction and production of peat and peat products.

Quarrying includes excavation and hydraulic extraction, while loosening refers to surface layer production [3, 8]. Both strategies require performing auxiliary operations. These include completion-preparation work (deposit preparation, repair of production areas, recultivation, and machine preparation) and associated work (maintenance, machine adjustment, supervision, quality assessment, and etc.). By performing auxiliary operations and processing of separated secondary materials secondary resources (timber, chips, peat moss, and peat water) are derived. Wooden chips can be used as fuel or as a material for mulching or surface levelling; both chips and moss find their use in construction (raw materials from upper undecomposed layer can be used in designs of filtering devices or as heat insulators); derived during peat dehydration process, peat water can be enhanced and then used as a fertilizer or as a component of various biologically active substances. Usage of secondary raw materials can increase the efficiency of production and lower its footprint [9, 10].

When excavation is performed, peat extraction is carried out at full or partial stratum thickness. Excavation can be performed through the following five processes: hand cutting, machine-cutting, and excavation with dredger, excavator, or bulldozer. These processes are performed with the help of corresponding technologies. The oldest methods of peat extraction are manual winning and hand cutting with specially designed simple cutters. Today, manual work has almost been replaced by machine-cutting, as using machinery significantly increases the productivity of peat winning process. Raw peat extracted by using this method has the least disrupted cloddy structure [4, 8].

Excavation can be performed with the use of dredgers or bucket chain excavators; peat mass excavated with this method requires further forming into lumps. Excavating stipulates the use of mechanical and hydraulic excavators, equipped primarily with backhoes, and rotary multi-bucket mining machines. Peat extraction with the use of bulldozers is also referred to excavation. This machinery shows itself best at thin peat deposits where raw peat is won by cutting layers with a bulldozer blade. Extraction performed through the use of bulldozers and excavators results in winning sod peat with disturbed (opposed to the peat won through the use of dredgers) structure which is deformed by a corresponding excavating body of a mining machine in course of deposit destruction.

Milled peat forming, like dredging, results in winning sod peat, but this method is referred to the group of loosening methods that are included in surface layer production strategy [11]. This strategy also includes milled peat method and passive loosening method. These methods do not allow extraction at full stratum thickness, as well as require the lowering of a water-table. Loosening results in winning milled peat with disrupted structure [12].

The last group of extraction methods includes hydraulic extraction methods and machinery necessary for their performing: hydraulic extraction, borehole hydraulic extraction, and hydraulic extraction with water jets. These methods stipulate that raw peat is flushed with water or mechanically separated from working face in order to form slurry that is pumped across to a drying field. These methods have several significant disadvantages, such as the necessity for massive amounts of water and high expenditure of effort going into raw material drainage and deposit preparation. These hydraulic extraction methods being performed result in winning slurry that consists of heterogeneous peat and water blend, where peat is present in the milled form with disrupted structure [13].

4. Systems for peat extraction and processing

Choice of mining machinery system depends on the type of raw material needs to be produced. Mining machinery system is a set of blocks, modules and machines integrated into a single chain. This interconnection becomes possible with the help of links providing coordination, connection, and coupling. There are nine systems that, being combined, allow performing peat extraction: extraction and processing, processing, deposit preparation, drainage, winning, recultivation, production area repair, subordinate and auxiliary systems, transfer-systems. Extraction systems are used for extracting raw peat from the deposit and, in case of milling technology, can include modules for extraction, harvesting, turning, drying, transfer, and auxiliary modules. Processing systems can be stand-alone or combined with extraction systems, in the second case scenario, they include modules for separation, dehydration, and production of saleable materials. These systems also can include a module for energy

generation, like the one described in patent [14], where floating mining systems that is able to process raw vegetation-peat material into fuel, that is further used in energy generation, thus allowing the system work autonomously. Transfer-system is used for transporting extracted materials. This system utilizes floating containers, conveyors, loaders, and etc. As peat deposits are located in boggy areas, drainage systems are required. Systems for deposit preparation and production areas repair make and maintain extraction work possible. Subordinate and auxiliary systems provide power supply for machinery to operate and are also used for secondary raw materials processing. Recultivation system is required to compensate the anthropogenic footprint left at deposit during peat production process.

Extraction block can include machines and devices of various types. For example, this block can include a hand cutter that is the most primitive tool for peat extraction. Excavators can extract peat at full stratum thickness and can be represented by different configurations: single-bucket excavators (with front shovel or backhoe), multi-bucket excavators (with rotary or chain drive), excavators with a grab. Bulldozers can be utilized for piling peat up to allow its further transportation, water jets for materials scouring and its further gathering with pumps, millers for surface layer method, screw millers for raw peat extraction and separation.

The necessity for recultivation is based on the environmental damage inflicted by dewatering operations performed in the course of traditional peat extracting. The damage affects flora and fauna in the production area. It is also worth noting that the dewatering process requires gigantic labour input and restricts production to particular seasons. The natural deposit needs approximately two years to be prepared for production commence, pay-off period can amount in more than ten years, though [15]. Taking all the disadvantages mentioned above, the conclusion can be made that a challenge of developing new technologies and systems for environment-friendly all year-round peat extraction within smaller areas is of utmost urgency [16, 17].

5. Conclusions

This article provides the single classification of methods for raw peat extraction and systems necessary for their performing. The classification is based on types of raw peat that are extracted from deposits with the help of various methods. Within the analysis, all the existing prospective solutions for mining equipment for environmental friendly peat extraction were presented.

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