An integrated approach to strip mining of peat

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Abstract. The innovative technology of peat extraction promoting power and resource-saving is offered. Completeness and complexity of peat field useful components extraction are provided on the basis of the nature protection principles of rational environmental management. Strip mining is the mining of a relatively flat field. Preparing the area after its drainage involves a basic series of technological procedures: collecting of wood wastes and removing to the storage, deep milling of the top layer; small wood residues collecting and removing to the area; field surface leveling and profiling (7 peat machines). Preparing the area after its drainage with the excavation of the top layer involves another series of technological procedures: collecting of wood wastes and removing to the storage, deep milling of the top layer; collecting and removing to the storage material for the top layer; field surface leveling and profiling (5 peat machines). In the proposed flowsheet with deep peat milling the top layer is loosened and mixed (roots of trees, shrubs, parts of grass and moss vegetation, woodchips, peat of small decomposition degree). Then the whole layer is removed from the peat field for special treatment. For peat production, there is an undisturbed peat deposit surface, clear of a waste layer.

1. Introduction
The effective option of peat deposits development should provide the maximum economic benefit from the use of the potential value of peat with a decrease in the impact on environment components [1]. The selection of an appropriate mining method is a complex task that requires consideration of many technical, economic and environmental factors. The appropriate mining method is the method that is technically feasible for the peat deposit conditions, while also being a low-cost operation [2].

Surface peat mining is the most common method of peat production in the world. New mining technologies can significantly improve mining efficiency and reduce the environmental impact. In general, mining techniques become much more environmentally sensitive when efficiency is improved because less waste is produced [3]. In this regard, the attention is paid to the research of the Freiberg Mining Academy and the University of Technology on the responsible mining concept and analysis of conventional and alternative mining approaches, maximizing the use of valuable components of a deposit (major, minor and accompanying minerals) [4].

The main characteristics of the general mining approach are:
• relatively high losses of valuable components;
• a high volume of waste material;
• negative impacts on the environment;

The main characteristics of the alternative mining approach are:
The general tendencies of alternative mining are higher income because of the reduction of losses and additional sellable products from byproducts and accompanying raw materials [4]. The complex development and rational use of peat deposits can be characterized as an economically effective combination of various production manufacture with a technologically and ecologically reasonable way of field preparation. At peat production take a significant amount of the wood remains which put in stacks near the peat field. The concentration of a large amount of the dry wood remains is an additional factor of fire danger on the peat field and surrounding territories. Thus, one of the main problems of the peat industry is the development of complex ecologically balanced technologies for the extraction and processing of all organic resources in the peat deposit. Advantages of complex use of peat deposits in comparison with the conventional mining approaches are confirmed by economic indicators for such production payback periods of capital investments decrease, the profitability of production increases, the capital productivity increases [5]. The purpose of this paper is to develop performance criteria for fleet selection in new surface mining of natural bio waste as a raw material for factory-made local fuel.

2. The evaluation studies
Preparation of the operational area for the milling method of peat extraction includes drainage of a peat massif, removal of wood, vegetation, and moss-grass. Surface peat mining operation can be thought of as consisting of two distinct stages, overburden removal, and peat exploitation. The methods used will depend on a number of factors, and the technique used for peat exploitation can be the same or different from that used for overburden removal. Peat deposit preparing and overburden removal play a key part in surface mines, accounting for up to half the total cost involved in peat exposure, excavation, and transportation [6].

Peat horizons with numerous subfossil stumps and roots of pine, frequently occurring in northern European peat bogs, are reveling periods with considerable pine growth on the bogs during the Holocene [1, 7, 8]. The horizons often cover a large part of the bog surface, making up a woodland phase in the bog’s development history [9]. The expansion of the raised bogs often killed trees in the process and preserved their remains under Sphagnum peat. Stumps content of peat deposits is characterized by the percentage of stumps volume and the remains of tree trunks in a peat deposit to its volume. The most part of buried wood is made by stumps, smaller - the remains of trunks of trees of coniferous breeds. Layers with wood and stumps in deposits can have several horizons of stumps. The depth arrangements of layers, their power, a form of stumps are characteristic of each type and structure of a peat deposit [10]. Stumps of coniferous breeds, especially pines, remain in a peat deposit for thousands of years, often without losing the initial durability and very strongly complicate the process of peat extraction.

The stump content of peat deposits reduces equipment productivity by preparation of peat fields for operation, stumps grubbing, repair of the areas, deepening of channels, etc. In the process of increasing the stump content of peat deposits the efficiency of a peat deposit decreases.

General characteristic of a stump content of a peat deposit: up to 0.5% – low stump content; 0.6-1.0% – average; 1.1-2.0% – above average; 2.1-3.0% – high; over 3% – very high stump content.

The stratigraphic analysis of a peat deposit by the example of the peat deposit Lamskoye, Tver region [11], shows that layers (horizons) with wood inclusions are characteristics of a peat deposit (Figure). The fundamental difference of technological schemes of preparation consists in a method of releasing a peat deposit prepared layer from wood inclusions. Now two methods are applied:

• grubbing when wood inclusions by means of various grubbers are taken from a deposit and are taken out of borders of the prepared area;
• deep milling at which the top layer of a peat deposit is milled at the depth of 0.4 m together with the wood inclusions which are in it. At the same time wood is processed into shaving by the size in several centimeters.
Peat deposit preparation is carried out now (90 - 95% of the total amount of field preparation) by the second method, i.e. with the use of deep milling machines. Small trees (up to 8 cm in the diameter) and branches, grass and moss cover and wood inclusions can be crushed into the peat layer to a depth of 40 cm using deep millers at simultaneous hashing and consolidation of milling layer. Application of this preparation method allows to reduce the number of operations and the number of technological machines, to have good technical and economic indicators at the rather high quality of the prepared fields. However, the high contamination of the prepared layer of the small wood particles worsens the quality of peat production [12].

3. A new method of peat field preparation

The preparation work of the operational area for the milling method of peat production includes drainage of a peat deposit, removal of wood, vegetation, and grass. Preparation of the areas is carried out generally with the use of preparing millers for deep milling of a top layer together with wood inclusions now that are connected with a rather low cost of preparation at the rather high quality of work performance. In the loosened layer after preparing miller, the greatest number (55-65% on weight) is wood pieces 0.10-0.25 m long. The number of wood pieces less than 0.1 m long does not exceed 15% of the total. Other pieces of wood spill meet with a ratio of length to width from 3:1 to 7:1 more often [10].

The wood in peat excavation fields, such as stem wood and stumps hinders the different stages of peat production. A significant part of the excavation sites contains so much wood, that it has to be removed by lifting it as one piece or by milling it among the peat. The miller of the machine is equipped with knives, which crush the wood to chips inside a field. The preparation miller also uses for the preparation of new peat production areas, where it, besides eliminating the problems caused by wood, also mixes the surface vegetation with underlying decomposed peat. Technical and economic factors favor milling-based processing of wood, especially deep milling with a preparation miller, which crushes wood among peat [12].
Preparing the area after its drainage involves a basic series of technological procedures: collecting of wood wastes and removing to the storage, deep milling of the top layer; small wood residues collecting and removing to the storage; field surface leveling and profiling. The table shows the technological procedures (after drainage network construction) of the peat deposit surface preparation with trees up to 0.8 m in diameter with the removal of small wood particles out of milled layer [10].

Table. Technological procedures of peat deposit preparing (with trees 8 cm thick)

| Technological procedures                          | Stripping machines (with the removal of small wood particles out of milled layer) | Stripping machines (with the removal of all milled layer) |
|--------------------------------------------------|--------------------------------------------------------------------------------|----------------------------------------------------------|
| Leveling of peat disposal                        | Bulldozer                                                                     | Bulldozer                                               |
| Collecting of wood wastes                        | Stumper-collector                                                             | Front end loader                                         |
| Loading of wood wastes in trailer                | Tractor clam-type loader                                                      | Front end loader                                         |
| Hauling of wood wastes to the storage            | Peat Field trailer                                                            | Peat Field trailer                                       |
| Top layer deep milling                           | Preparing miller                                                              | Preparing miller                                         |
| Small wood collection in stockpiles              | Small wood collector                                                          | Bulldozer                                               |
| Loading small wood in a semi-trailer             | Tractor clam-type loader                                                      | Front end loader                                         |
| Hauling small wood to the storage                | Peat Field trailer                                                            | Peat Field trailer                                       |
| Stockpiling wastes on the storage                | Tractor clam-type loader                                                      | Front end loader                                         |
| Peat field surface levelling                     | Screw leveler                                                                | Screw leveler                                             |

For the conventional technological preparing procedures, the fleet consists of 7 machines, including 3 pieces of general-purpose equipment (wide-tracked bulldozer; peat field trailer; tractor clam-type loader) and also 4 peat machines of highly specialized purposes (stumper-collector; preparing miller; small wood collector; screw leveler).

Thus, in the usual flowsheet with deep peat milling, the top layer is loosened and mixed (roots of trees, shrubs, parts of grass and moss vegetation, woodchips, low-quality fibrous peat). Then the small wood particles are removed from the milled layer. At the beginning of peat production, it is necessary to perform preliminary cycles for the harvesting of these wastes, which is not practically used [13]. According to the principle of wise use of peatlands, the criteria for the sustainable use of peat resources should be fulfilled [14]. The wise use of peatlands should be fulfilled at all stages of the lifecycle of peat production – before production is started, at the preparation stage, at the production stage and after production ceases before moving on to the next form of land use. All biowaste should be removed especially when a production area is at the preparation stage. It is the full recycling process of waste after peat deposit preparation.

For the proposed flowsheet (Table), the fleet consists of 5 machines: including 3 pieces of general-purpose equipment: [13] (wide-tracked bulldozer; peat field trailer; front end loader) and also 2 peat machines of highly specialized appointment (preparing miller; screw leveler).

Stages of complex mining of the peat field include operations on overburden with the removal of the waste layer and operation of peat mining. At the first stage of deep continuous milling of the peat deposit top layer with a forest stand, the vegetable remains and wood inclusions are made. The entire milled layer is removed out of the production site. In the process of peat deposit excavation, there is deep milling of the horizons with wood inclusions. After deep milling, these layers are also removed out of the borders of the production site. For peat production, there is an undisturbed peat surface, clear of a waste layer.

The given complex peat mining differs in full use of all resources of the peat deposit with the reduction of the peat preparing fleet. The area is ready for peat production and all biowaste from the top layer (wood particles, mosses, grasses, and low-quality fibrous peat) is removed and collected for further
processing. The mine plan and layout of storage place therefore always look to minimize the hauling distance required for transport of peat and removal of overburden material. Storage places are therefore normally installed closer to the mine open-pit, sometimes several kilometers far away from the peat fields.

4. Conclusion
This paper has explained the development of improved methods of peat deposit preparing that are intended to provide guidance for engineers involved in the design and construction of peat mining. In this article, we present available machinery and new approaches to biomass (wood and plant wastes) harvesting. Mining techniques have been discussed under two major aspects of peat mining: overburden removal and peat production. Biowaste of the top layer can be processed into local fuel or agricultural products. Application of technical and technological improvement will allow one to increase equipment productivity, reduce the cost of conducting overburden works and increase the profitability of mining on the peat fields with wood inclusions. Thus, the given complex peat mining differs in full use of all resources of the peat deposit with the reduction of the peat preparing fleet.

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