Aspects of excavated peat compacting in quarry

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Abstract. The article discusses the factors influencing the decrease in the dependence of the extraction of excavated peat raw materials on weather conditions. The main constituent phases of the peat composite are presented. Quantitative and qualitative analysis of peat density transformation has been made. Main phases of the peat composite are described in the paper including the main goal and application of field compacting of the excavated peat method. The features and effectiveness of this method are considered.

1. Introduction

In Russia, there is a huge number of low-decomposition peat reserves that are in demand on the world market, but the existing technology of peat extraction and storage cannot provide the required quality of products, due to the loss of peat consumer properties (the appearance of a specific smell, darkening, reduction in moisture absorption capacity) during these processes. Wet raw materials transportation cost is not comparable to extraction cost [1].

The change in the use of peat raw materials, primarily in the direction of its subsequent mechanical, thermo-mechanical, thermo-chemical and biochemical processing to obtain a wide range of final output, revealed the need to develop technologies and equipment [2].

One of requirements for creating a technology for extracting peat raw materials is to provide supplies of peat products in the required volumes for the consumer at a given quality regardless of weather conditions. Increasing the efficiency of the main processes of peat extraction should rest upon maximizing the use of solar energy and air masses, increasing peat extraction rate and its quality, and reducing transport costs [3].

Peat is very soft, easily penetrated organic soil and unstable material. According to the Unified Soil Classification System (USCS), peat is a highly-organic soil. Particles of leaves, grass, branches, or other fibrous vegetable matter are common components of these soils [4]. Removal of peat is the most commonly used procedure for peat excavation. An excavator method of peat mining is conducted in the vertical direction, practically throughout its depth [5].

A raw peat material can be excavated with no difficulty using a hydraulic backhoe. The material flows very easily and must be supported and contained to be excavated to any significant depth [6]. Mostly, equipment of cyclic action for excavating and loading is used on open pits.

Technological operations of open-cast peat excavation can be divided into two parts: the first covers operations for the excavation of peat raw materials from a peat deposit, the second – operations for loading peat raw materials from bulk materials into vehicles and laying it for drying. The following article covers the second part of the operations, in which peat raw materials are loaded from heaps with
subsequent pelletizing. The latter, depending on the technology, involves loading peat into a compacting machine, peat compacting and drying [7, 8].

The aim of the research is to increase the efficiency of peat raw material extraction with subsequent molding into rectangular aerated compacts in order to reduce transport costs of wet excavated peat raw materials in compacts (volumetric forms produced by compression) and to accelerate the natural drying process.

2. Materials and methods

These tasks can be done using peat compacting technology, which allows one to combine the advantages of milled and sod methods of peat extraction. This is possible by excavating peat raw materials from the deposit, separation of wood inclusions, compacting excavated peat raw materials at relatively low pressures and laying on the field in high drying conditions. The following steps allow one to increase the intensity of evaporation up to 90%, reduce weather condition influence, extend the production period due to spring and autumn months inclusion, prolong the drying period of products for the entire year, including winter freezing of moisture from compacts, and minimize the cost of intra-mass transportation of raw materials [3, 9].

One of the main factors of peat compacting is the bulk density of the material, which raises with the increase of applied pressure to the peat raw material [5, 7].

To adjust peat compact density and strength, it is required to know the initial density of peat in the deposit and the density of excavated peat. The density depends on the properties that the peat has in the deposit, such as humidity, degree of decomposition, botanical composition and structure. In natural conditions, the deformability of a peat deposit mostly depends on the presence of a fibrous mass forming a spatial framework. Therefore, when evaluating the mechanical properties of activated peat, the ratio of the fibrous mass and the fine fraction is a key factor [11, 12].

The need for peat compacting arises when its volume is significant, and the bulk density is relatively low. Excavated peat raw materials with a low-disturbed structure have a low bulk density due to loosening effect and the presence of air phase, but it is very compressible. Main characteristics of the compressing equipment depend on peat properties [13, 14].

The natural density of unconsolidated peat deposit of the lowland type in the quarry mining method varies from 710 to 1020 kg/m³ depending on the humidity and the degree of decomposition of peat; the density of unconsolidated peat deposits of the upper type varies from 725 to 1020 kg/m³ (Table 1) [1, 15].

### Table 1. Operational humidity of a peat deposit in the excavator method of peat production

| Decomposition, degree of peat, % | Operating humidity (%) for the type of peat deposit | Lowland | Riding and transitional |
|-------------------------------|----------------------------------|---------|-----------------------|
| 15-20                         |                                  | 88.5    | 89.0                  |
| 21-30                         |                                  | 87.5    | 88.5                  |
| 31-40                         |                                  | 87.0    | 88.0                  |
| >40                           |                                  | 86.0    | 87.0                  |

Figure 1 presents a scheme of sequential quantitative and qualitative transformation of peat from its natural condition to peat deposits (in situ) conditions by:

- excavation of peat raw materials using the excavator (with averaging and loosening);
- unloading in bulk (with some compaction);
- mechanical compaction of peat raw materials.
Figure 1. A scheme of the sequential quantitative and qualitative transformation of peat raw materials.

A peat composite compact (fig. 2) is a material consisting of a continuous phase – matrix (a peat microstructure, composing from supermolecular formations of decomposition products - fig. 3a), a discrete phase (macrostructures – easily deformable interlacing structures - fig. 3b) and an interphase boundary.

Figure 2. Peat compact model

Figure 3. Types of source material of peat compact:
a) matrix (a peat microstructure, composing from supermolecular formations of decomposition products); b) discrete phase (macrostructures – easily deformable interlacing structures)
The need for compaction of peat arises when its volume is significant, and the bulk density is relatively low. Excavated peat with a little disturbed structure has a low bulk density due to loosening during excavation and the presence of an air phase, but has a high degree of compressibility.

The main mechanisms of the interphase interaction of the reinforced filler-matrix during peat compacting should be the interweaving of macrostructures and mechanical coupling in the material when compressive and shear loads are applied [16, 17].

Peat composites are natural in origin, but in the course of equalization, mixing and dispersing processes during excavation and subsequent compacting, they become artificial with the increase of structure strength and crack resistance, as well as the preservation of compact’s shape [18].

3. Features of compaction of peat raw materials
The process of peat compaction is adjacent to change of its water and gas permeability, and even the application of relatively small loads leads to a significant decrease of the porosity coefficient [19].

Technical-economic study has shown that costs of field peat producing are comparable to transport costs, especially when the moisture content of excavated peat is relatively high. The main requirement for the implementation of the technological process is to bring the laying and drying sites as close as possible to the excavation site. In this case, peat excavated from the entire depth of the deposit is mixing and equalizing in an excavator bucket, and then compacting and drying near the quarry [20].

Reducing the influence of weather conditions on compacted peat production is provided by a number of factors:

- the technology is simplified; there are no repeated and cyclic operations in the technological process, which depends on weather conditions;
- the use of favorable weather conditions (solar radiation and air mass potential): drying in the spring-summer-autumn period and freezing of moisture in winter months;
- drying and storing of peat in high aerated lumps reduce peat wetting and storage losses.

Due to the increase in the depth of the deposit in the quarry method and the increase of the mining season duration, the seasonal production of compacted peat per unit area can be increased 2-4 times compared to that of the milled and sod methods. The absence of additional operations after drying even in winter months (due to sublimation) increases the technological reliability of production [21, 22].

Compacting of loosened and equalized peat with an intact structure and subsequent drying in an aerated stack significantly changes the water-air and thermal conditions of the compact, which minimizes the transformation of the organic matter of peat (fig. 4).

![Experimental peat compact with aeration holes](image)
The process of peat extraction with field compacting is an environmentally friendly process due to:

- reducing air dustiness in the area of peat extraction;
- reducing water contamination of fine peat particles.

Peat compacting can be carried out in various regions, including areas with seasonal freezing [23].

4. Conclusion

Minimal processing peat excavation and separation, compacting at low pressures and natural radiative-convective drying in soft mode allow one to produce high-quality products with various consumer properties for both subsequent processing and export deliveries.

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