Production and Technological Parameters of Milled Peat Extraction Depending on Organization of Peat Machines Operation

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Abstract. The article presents two options of organizing the technological process of milled peat extraction with due consideration of weather conditions for peat drying. The first option of the technological process is the extraction based on cycle peat harvesting differentiation. The developed technological process of milled peat drying in thick layers based on pneumatic peat harvesting allows us to organize a technology of peat extraction with a constant cycle time, avoiding the necessity for drying rate prediction. This is due to the fact that under good weather conditions the spreading thickness of 45-50 mm is sufficient to maximize the number of harvesting cycles. Milling at roughly equal depths forms the basis for the second option of technological process. The article presents the methodology of calculating such technological parameters as cycle and seasonal harvesting, number of cycles and seasonal productivity of a harvesting machine. Seasonal harvesting and seasonal productivity of a harvesting machine are calculated by technological design standards. The analysis of calculations revealed that in the process of milled peat extraction based on cycle harvesting differentiation, it is necessary to apply coefficient 0.9 that takes into account the organization of harvesting machines operation.

1 Introduction

The organization of mining processes goes hand in hand with a specific production technology. Therefore, many of the peat production organizational tasks must be carried out in the light of existing technological requirements and regulations. However, there is significant difference between technology and organization. The organization/ implies the development of methods for the best process implementation, while the technology is provided for the methods of changing a production object (in the technological process under consideration a production object is a peat deposit). The ultimate goal of organizational measures is to develop recommendations for ensuring the most effective performance of technological processes. In peat production, organizational measures are aimed at improving the cycle and seasonal harvesting of milled peat, as well as at increasing the productivity of technological machines.

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2 Method Used

On evidence derived from the previously developed organizational recommendations, a technological process of milled peat production can be carried out according to one of two options, in view of weather conditions for peat drying [1 - 3]. The first option of the technological process implies a constant cycle time, i.e. time from peat milling to harvesting inclusively. This can be achieved by the milling depth differentiation depending on weather conditions. The technological process according to the first option involves the prediction of weather conditions and the compulsory milling depth control in order to get a calculated milled peat harvesting per cycle.

The second option of the technological process is based on approximately equal milling depth, which should correspond to the mean type of drying days. Under the second option, on good drying days peat dries out before the planned period and cannot be completely removed, since the design number of machines is determined by the planned cycle time. On weak drying days, the cycle time increases and peat machines idle due to the lack of spread of work.

Design organizations making production and technological calculations provide for a constant cycle time, i.e. use the first option [4 - 6]. According to this option, it is necessary to predict weather conditions for each upcoming cycle, determine the actual moisture content of the fragmented peat after milling and calculate the necessary milling depth. However, due to low probability of predicting the rate of milled peat drying in the upcoming cycle and inability of current milling machines to maintain the design milling depth in production conditions, the first option of technological process has not been implemented. At the production sites, peat deposit is milled to approximately equal depth, with this important parameter being monitored visually.

Developed by [7] a technological process for milled peat drying in thick layers based on pneumatic peat harvesting allows us to organize the technology of peat extraction with a constant cycle time avoiding the necessity for drying rate prediction, as in good weather conditions the spreading thickness of 45-50 mm is quite sufficient to achieve the maximum possible cycle harvesting.

In the design project, normative seasonal harvesting (t / ha) of milled peat is calculated by the formula:

$$q_{ns} = q_{nc} n_{nq} \tag{1}$$

where q_{nc} –normative cycle harvesting, t/ha; n_{nq} – normative quantity of cycles.

The normative cycle harvesting is calculated for the mean type of drying days, i.e. with disregard for the milling depth differentiation. The normative quantity of cycles is determined by the condition of a constant drying time (two days), but without consideration of harvesting machines operations [8, 9].

The design seasonal tonnage productivity of a harvester is also calculated for the mean type of drying days as follows:

$$G_s = S_h q_{nq} t_{sh} \tau_c n_{nq} \tag{2}$$

where S_h – productivity of a harvester with normative (average) cycle harvesting, ha/h; t_{sh} – design number of service hours per day; τ_c – planned cycle time of a cycle, day.

This suggests that when we calculate the seasonal productivity of harvesting machines, the option of organizing the technological process based on cycle harvesting differentiation is also beyond consideration [9, 10].

With the introduction of a technological process based on cycle harvesting differentiation, the hour productivity per hectare of the harvesting machine depends on the amount of peat that will be dried during a cycle design time. Because of varying harvesting capacity of a peat machine, to harvest peat over the entire area will require different running time per day [11, 12].

In consideration of the technological process of milled peat extraction of the first option (based on milling depth differentiation), we have developed the following methodology of calculating the key technological parameters – cycle and seasonal harvesting, number of cycles and seasonal productivity of a harvester. We take the seasonal design productivity of a harvester as the main production and technological parameter that is recommended to calculate by summing up the amount of peat harvested within the periods of approximately equal drying rate during a harvest season, using the following formula:

$$G_{sd} = \sum_{i=1}^{n} \left(S_{hi}\, q_{ci}\, t_{di}\, T_h\, K_i \right) \qquad (3)$$

where G_{sd} – seasonal productivity of a harvester in the technological process based on differentiation of cycle harvesting, t; $i = 1, 2, 3, ..., n$ – number of intervals with effective evaporation from the surface of the soil evaporator per day; S_{hi} – productivity of a harvester in cycle harvesting q_{ci}, ha/h; q_{ci} – cycle harvesting calculated with the average value of effective evaporation in the i-th interval, t / ha; t_{di} – design number of the machine service hours per day in the i-th evaporation interval; T_h – normative number of harvesting days; K_i – relative frequency of effective evaporation harvesting days in the i-th interval.

The area in hectares per harvester is taken as a constant for the entire season and determined by the formula:

$$F_c = S_h\, t_d\, \tau_c \qquad (4)$$

where S_h – productivity of a harvester under cycle harvesting designed for mean weather conditions, ha / h;

t_d – design number of service hours per day; τ_c – planned cycle time, the day.

The design number of service hours of a harvester per day in the i-th interval is determined by the formula:

$$t_{di} = \frac{F_c}{S_{hi}\, \tau_c} \qquad (5)$$

The total number of service hours of a harvester for a season and the area harvested are calculated by formulas:

$$T_s = \sum_{i=1}^{n} (t_{di} T_h K_i) \qquad (6)$$

$$F_s = \sum_{i=1}^{n} \left(S_{hi} t_{di} K_i \right) \qquad (7)$$

The design number of cycles with cycle harvesting differentiation and the design seasonal harvesting (t / ha) are determined by formulas:

$$n_{cd} = \frac{F_s}{F_c} \qquad (8)$$

$$q_{sd} = G_{sd} / F_c \qquad (9)$$

The weighted average for a cycle harvesting (t / ha) is as follows:

$$q_{cd} = q_{sd} / n_{cd} \qquad (10)$$

The thirty-year past data of Moscow meteorological measurement series were taken to determine a relative frequency of the effective evaporation intervals. All the harvesting days with effective evaporation rate ≥ 1.6 kg / m² were distributed into 7 intervals (Table 1). The harvesting days were determined according to the methodology of the All-Russia Research Institute of the Peat Industry.

The design cycle harvesting with the milling depth differentiation was determined by the formula:

$$q_{ci} = 10 P_d \left(1 + W_c\right) \alpha_c \qquad (11)$$

where P_d – specific load of fragmented peat after milling in terms of dry basis, kg / m²; W_c – conditional moisture content of the finished product, kg / kg; α_c – cycle harvesting coefficient.

Given that all the conditioned peat is to be harvested, the theoretical translation velocity (m / s) of a pneumatic harvesting machine was calculated by the formula:

$$V_{Ti} \leq \frac{10\,h\,\gamma_a\,\mu\,V_{an}\,(100-w_{hp})}{q_{ci}\,K_v\,(100-w_c)} \quad (12)$$

where 10 – conversion factor from kg / m² to t / ha; h – height of the nozzle entrance slit, m; γ_a – air density, kg / m³; μ – mass concentration (the ratio of peat mass to mass of air bearing it); V_{an} – velocity of the air mixture at the nozzle entrance, m / s; w_{hp} – moisture content of the harvested peat,%; q_{ci} – design cycle harvesting, t / ha; K_v – tractor velocity factor; w_c – conditional humidity,%.

The hourly productivity of a pneumatic harvester was determined by the formula:

$$S_{hi} = 0.36\,V_i\,K_v\,b_d\,K_w\,K_c\,K_e \quad (13)$$

where V_i – nominal speed of a harvester, m / s; b_d – design operating width, m; K_w – operating width factor; K_c – cycle time factor; K_e – harvester efficiency.

3 Results and Discussions

When calculating the harvesting area for a single machine, we assumed the maximum operating time per day to be 16 hours. If harvesting is organized in two shifts by 7 hours, with the actual technical readiness coefficient of pneumatic machines being 0.70 - 0.85, the average seasonal operating time does not exceed 16 hours per day.

All calculations are summarized in Table 1. According to the process engineering standards, the design values are as follows:
• seasonal harvesting q_s = 12.0 · 46 = 552 t / ha
• harvester productivity per season G_s = 1.34 · 12.0 · 16 1 · 46 = 11 835 t
• harvesting area for a single harvester F_c = 1.36 · 16 · 1 = 21.5 ha.

Table 1. Production and technological parameters for pneumatic harvesting of milled peat based on cycle harvesting differentiation process.

Evaporation per day, kg /m²			Cycle harvesting, t / ha	Nominal speed m /s	Productivity, ha / h	Number of service hours		Productivity	
Intervals	Average value	Relative frequency				per day	per season	ha	t
1.6 – 2.5	2.05	0.045	6.30	2.37	1.53	14.1	29.2	44.7	281.5
2.6 – 3.5	3.05	0.175	8.49	2.37	1.53	14.1	113.5	173.7	1474.3
3.6 – 4.5	4.05	0.200	10.50	2.37	1.53	14.1	129.7	198.4	2083.6
4.6 – 5.5	5.05	0.259	12.39	2.07	1.34	16.0	190.6	255.4	3164.5
5.6 – 6.5	6.05	0.206	14.19	1.68	1.08	16.0	151.6	163.7	2323.3
6.6 – 7.5	7.05	0.080	15.91	1.68	1.08	16.0	58.9	63.6	1012.1
7.6 –	8.0	0.035	17.58	1.26	0.81	16.0	25.8	20.9	367.4

8.5	5							
Total	1.000					699.3	920.4	10706.7

Design values for the technological process based on cycle harvesting differentiation:

• harvester productivity per season G_{cd} =10 707 t

• seasonal harvesting q_{sd} = 10 707 / 21.5 = 498 t / ha

• number of cycles n_{cd} = 920.4 / 21.5 = 42.8

• cycle harvesting q_{cd} = 920.4/42.8=11.63 t / ha.

Table 2 shows the final results of the calculations.

Table 2. Final production and technological calculations.

Parameters	By design standards	Based on cycle harvesting differentiation	
		value	reduction, %
Number of cycles	46	42.8	6.96
Cycle harvesting, t / ha	12.0	11.63	3.98
Seasonal harvesting, t / ha	552	498	9.78
Harvester productivity per season, t	11 835	10 707	9.53

As shown in Table 2, when calculating the seasonal harvesting and the seasonal productivity of harvesting machines according to the process engineering standards for the process based on the cycle peat harvesting differentiation, we have to introduce a reduction factor K_d = 0.9.

4 Conclusions

Thus, the methodology for calculating cycle and seasonal harvesting, number of cycles and seasonal productivity of a harvesting machine have been proposed. It takes proper account of the location areas of peat production, weather conditions for fragmented peat drying. The analysis of the production and technological calculations has shown that in the process of milled peat extraction based on cycle harvesting differentiation, it is necessary to apply a coefficient that takes into account the organization of harvesting machines operation.

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