

# METHODICAL BASES FOR SELECTING PARAMETERS OF POST-HARVEST GRAIN PROCESSING POINTS BASED ON STATISTICAL SIMULATION

## МЕТОДИЧЕСКИЕ ОСНОВЫ ВЫБОРА ПАРАМЕТРОВ ПУНКТОВ ПОСЛЕУБОРОЧНОЙ ОБРАБОТКИ ЗЕРНА НА ОСНОВЕ СТАТИСТИЧЕСКОГО ИМИТАЦИОННОГО МОДЕЛИРОВАНИЯ

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**Abstract:** Developed method rationale parameters equipping items postharvest processing of grain under the coordination of programs with the characteristics of industrial harvesting of early grain crops and grain systems parameters given the variability of agrometeorological conditions of the region.

**KEYWORDS:** POSTHARVEST PROCESSING OF GRAIN ITEM, PROCESS, SYSTEM, PARAMETERS, STATISTICAL SIMULATION.

### 1. Introduction

During the production of field crops, namely in the final stages of production, there is a number of negative phenomena - the loss of crops by farms due to untimely harvesting is more than 9,6% [9], the loss of harvested crop due to the untimely post-harvest harvest of 10-30% [10], As well as high costs associated with the inefficient use of appropriate technical equipment, energy and labor resources.

Improve the efficiency of mechanized harvesting and post-harvest processing processes due to the systematic coordination of the characteristics of production plans for harvesting early grain crops, the parameters of the grain harvesting complexes (TPP) and the parameters of the technical equipment of the corresponding points (P POZ), taking into account the stochastic influence of agrometeorological conditions. This will allow you to perform the specified technological processes with a minimum total specific cost of funds.

### 2. Preconditions and means for resolving the problem

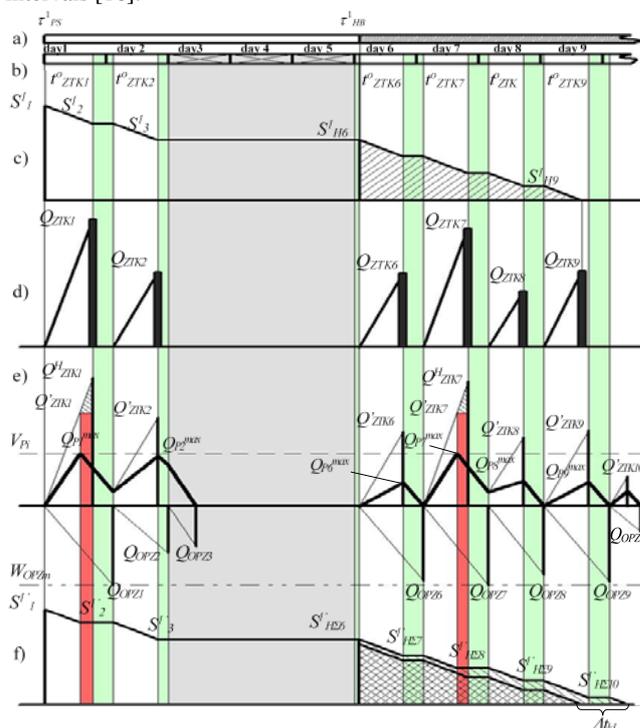
Today developed many scientific and methodological approaches to justify the logistics processes of gathering early grain crops [11-17, 24] and postharvest processing of grain [18-20]. However, no approach systematic study parameters equipping P POZ positions, which would take into account the variability of the flow characteristics of grain on point throughout the day, due agrometeorological conditions of the region, the characteristics of harvesting and transport facilities and features of their operation and reverse effect on the functioning of these systems process postharvest Grain processing. Therefore, there is the problem of developing methods justification parameters P POZ technical equipment, which will take into account the cumulative effect of a plurality of the aforementioned factors.

### 3. Results and discussion

The basis of the development of a methodology for justifying the parameters of technical equipment for post-harvest grain processing are based on previously established methods for justifying the parameters of the technical equipment of technological systems for the collection of early grain crops (TS ZRZK)[11, 16] and post harvest cultivation of grain (TS POZ) [21]. These methods are based on statistical simulation of the corresponding technological processes and take into account the stochastic influence of the factors of their efficiency on the course of the corresponding processes.

The simulation of the TS ZRZK takes place in a discrete-event approach. Accordingly, a plurality of variants of reaching early grain crops are formed, as well as for each crop the time of occurrence  $\tau_{HB}$  losses is determined (Fig. 1, 2, a). On the basis of the distributions of the start and end time of the cloudy intervals, a plurality of variants of alternation of these intervals are formed (Fig.

1, 2, b). For each good model day, the actual fund of working time, as well as the nature of the air humidity deficit change during this day, is determined for each variant of the weathered and subtropical intervals [16].



**Fig.1.** Graphical interpretation determine the impact of post-harvest grain handling process to combine on a single field:

□ - duration of rainy periods of time; □ - duration of the dew period; ■ - duration of downtime ZTK due to delay in servicing the grain flow to the P POZ; a) option ripening grain crop in the field; b) a fine option and rainy periods; c) graphical representation of the decrease in the volume of the unassembled area of the field as a result of grain harvesting; d) graphical representation of the daily formation of grain flow per item without taking into account the influence of the functioning of the technological system of post-harvest grain processing on the grain harvesting process; e) graphical representation of the service of grain flow at a point with given parameters and its influence on the grain harvesting process; f) graphical representation of the decrease in the volume of the unassembled area of the field as a result of grain harvesting, taking into account the impact on it of the TP POZ.

In the process of simulation of the day-to-day operation of the TS ZRZK due to the reduction of the unassemble area of the field under the grain crop (Fig. 1, c), the daily flow of grain is formed up to P POZ (Fig. 1, d). It is characterized by quantitative (daily volume  $Q_{ZTK}$ ), temporal (duration of receipt of the flow of the organizationally adjusted working time ZTK  $t_{ZTK}^o$ ) and qualitative

characteristics: the nomenclature (culture, variety)  $\eta_j$ , humidity  $w(\tau)$  and debris  $\varphi(\tau)$  of grain at a certain time  $\tau$ . The stochastic influence of agrometeorological conditions on the work of the ZTK in a separate day, as well as on the change in the characteristics of grain stem blasts, causes a probabilistic change in the characteristics of the daily grain flow to item [22]. Therefore, the volume and duration of the flow of grain every day are different (Fig. 1, d).

If we simulate the operation of the TC ZRZK for each day of harvesting the plurality of the seasonal program fields, we obtain a variation in the values of the unloaded areas  $Z_n$  of each culture and the number of realizations in which these volumes occurred. The resulting variation series is used to construct an empirical function of the distribution of unplanned areas collected  $Z_n$  in corresponding realizations [11, 16].

The quantitative estimation of the probability of untimely gathered areas ( $P[Z_n > 0]$ ) during the harvesting of early grain crops is defined as the proportion of the number of implementations (seasons) of the model when there was a delay in the collection ( $n[Z_n > 0]$ ) to the total number of realizations of statistical simulation. The model [16]:

$$(n_p) - P[Z_n > 0] = n[Z_n > 0] / n_p.$$

In order to evaluate the efficiency (timeliness) of grain harvest operations without taking into account the influence on their operation, the generalized volume of unplanned areas collected (its mathematical expectation) should be determined, which characterizes the average amount of untimely gathered areas in all implementations of TP ZRZK:

$$Z_n = M[Z_n] \times P[Z_n > 0]. \quad (1)$$

System analysis of integrated technological systems for the collection of early grain crops and post-harvest treatment shows the mutual influence of these systems on one another in the process of their functioning. In particular, there is a reverse effect of the technological processes of post-harvest grain processing on the course of grain harvesting [23]. In the first place, it is conditioned by the parameters of the subsystem pre-cleaning of the TS POZ (P OPZ) by the performance  $m$ -th machine pre-cleaning of grain  $W_{OPZm}$  and the capacity of the  $i$ -th reserve volume  $V_{pi}$ . The productivity of the machine  $W_{OPZm}$  determines the intensity of the service of the incoming grain  $Q_{ZTKj}$  flow in the  $j$ -th day and the possible daily volume of the purified grain  $Q_{OPZj}$  (Fig. 1, e). The capacity of the reserve volume  $V_{pi}$  should be such as to ensure the full utilization of the daily working time of the machine of pre-cleaning the grain. That is, on a separate day, it should provide a technological reserve of crude grain at the time of the absence of the flow of grain per item as a result of the impossibility of performing the TP ZRZK due to the appearance of bad weather periods (deposition of dew) (Fig. 1, e).

It should be noted that the duration of the idle time of the combine harvester is influenced by: 1) the intensity of servicing the grain flow by the machine of preliminary cleaning of the given productivity, taking into account its change from the qualitative characteristics of the grain in the reserve volume, which determines the length of stay of the TZ in the queue for unloading; 2) the duration of filling the hopper of the combine harvester, taking into account the field performance characteristics, on which his work is modeled; 3) the duration of the transfer of TZ from the point to the combine, which depends on the distance of this move.

Due to the occurrence of ZTK downtime caused by the untimely service of the grain flow at the point, the length of the collection of a separate  $\gamma$ -th field ( $\Delta t_{k\gamma}$ ) and, correspondingly, the amount of untimely collected areas will increase. Therefore, the harvesting of the crop in the considered field will end not on the 9th day ( $S'_{H_29}$ ) (Fig. 1, c), but on the 10th day ( $S'_{H_210}$ ) (Fig. 1, f). It should be noted that the obtained values of late-assembled areas ( $S'_{H_26} \dots S'_{H_210}$ ) collectively characterize the efficiency of the technological processes of harvesting grain on a separate field and its post-harvest processing.

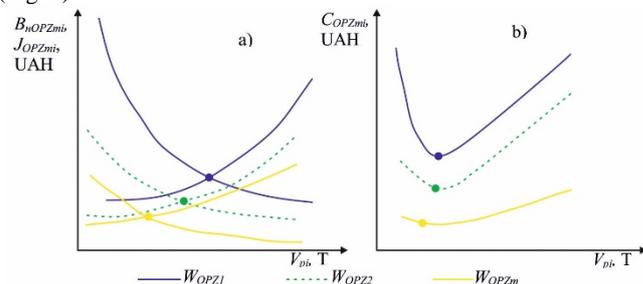
In order to assess the impact of the TS POZ on the operation TS ZRZK on a separate field, it is necessary to find the difference in the volumes of late-assembled areas received as a result of the cumulative functioning of these systems ( $\sum S'_{H_2j}$ ) and the

operation of the TS ZRZK ( $\sum S'_{H_2j}$ ) alone, as well as the increase in the length of the collection of this field due to the impact of the TS POZ ( $\Delta t_{k\gamma}$ ). The determined indicators allow estimating the losses of the cultivated yield on a given field, caused by the influence of the TS POZ on the operation TS ZRZK.

To assess the statistical regularities of functioning TS POZ on the functioning TS ZRZK should determine the likelihood and statistical evaluation of changes in the amount of time harvesting area and increase durations harvesting of early grain crops in certain fields, due to this influence during set seasons (iterations of a simulation model). This will allow to determine the statistical estimations of the generalized volume of untimely collected areas. Conversion of these areas based on length growth duration of the grain will work to assess crop losses grown  $B_{uOPZ.mi}$  as a result of the impact TS POZ set parameters  $m$ -th grain cleaning machines and  $i$ -th reserve volume P OPZ operation on TS ZRZK.

The next stage of justification of the rational parameters of the technical equipment of the item is to determine the direct operating costs  $J_{OPZ.mi}$  for the functioning of the pre-cleaning subsystem with the given parameters  $W_{OPZm}, V_{pi}$ . For this purpose, according to known methods, the expenses for the salary of the servicing personnel of the machine for preliminary cleaning of the grain and the reserve volume, the cost of depreciation of the specified grain cleaning machine and the reserve volume, as well as the expenses for electricity, maintenance, current and capital repair of the specified technical equipment of P OPZ.

Knowing the total crop losses in the monetary equivalent  $B_{uOPZ.mi}$  and direct operating costs  $J_{OPZ.mi}$ , the total costs  $C_{OPZ.mi}$  operation P OPZ with the given parameters are determined (Fig. 2).



**Fig. 2.** Graphical representation of the comparison of cumulative harvest losses in cash equivalent, direct operating costs (a), and the determination of aggregate costs (b) for the operation of P POZ with different parameters (grain cleaning capacity  $W_{OPZm}$  and reserve capacity  $V_{pi}$ ) and the choice of rational values of these parameters

The total costs  $C_{OPZ.mi}$  due to the use of a given  $m$ -th grain cleaning machine and  $i$ -th reserve capacity will be:

$$C_{OPZ.mi} = B_{uOPZ.mi} + J_{Opz.mi}. \quad (2)$$

According to the results of statistical simulation of the technological systems of harvesting early grain crops and post-harvest grain processing for the given characteristics of the production program and the parameters of the ZTK, for each of the plurality of variants of the technical equipment of the P OPZ the total costs are determined  $C_{OPZmi}$  (Fig. 2).

The analysis of the received dependencies of the change in the total cost  $C_{OPZmi}$  operation of the P OPZ with different parameters of the parameters allows us to justify the optimum capacity of the reserve volume for each pre-purification machine and determine the rational parameters P OPZ in which the value of these costs will be minimal:

$$Z_{OPZ} \rightarrow Z_{OPZ}^p, \text{ якщо } C_{OPZ.mi} \rightarrow \min. \quad (3)$$

However, the rational parameters  $Z_{OPZ}^p$  will not always be rational for the whole TS POZ. Therefore, the next step in justifying the rational parameters of the technical equipment of the item is the coordination of the specified variants of the parameters of the subsystems of preliminary purification and drying of grain (P SZ).

In order to calculate the parameters P SZ (productivity of the grain dryer  $W_{ZSm}$  and the necessary capacity of the reserve volume for its functioning  $V_p^{sw}$ ) it is necessary to establish statistical estimates of the daily grain volume per dry matter  $Q_{ZTKT}^{sw}$ , the humidity of this grain  $w_j$  and the length of its arrival  $t_{ij}^{sw}$  in this day, taking into account the impact on the grain harvesting process  $m$ -th grain cleaning machine. These estimates are determined on the basis of statistical simulation modeling of the technological processes of harvesting and post-harvest processing for the given production characteristics of the fields of the economy and agro-meteorological conditions in the region, technical support of these processes.

Knowing the estimation of the mathematical expectation of the daily grain volume to the point requiring drying  $\bar{M}[Q_{ZTKj}^{sw}]$  and estimating the mathematical expectation of the length of its processing in a separate day  $\bar{M}[t_{noj}^\phi]$  can be determined by the necessary hourly productivity of the grain dryer:

$$W_{ZSm}^g = \frac{\bar{M}[Q_{ZTKj}^{sw}]}{\bar{M}[t_{noj}^\phi]}. \quad (4)$$

Depending on the duration arrival  $t_{ij}^{sw}$  of moist grain during the day, its daily volume and grain dryer performance, provided that the grain has to be pre-cleaned ( $W_{OPZm}^g \geq W_{ZSm}^g$ ), the necessary capacity of the reserve volume is substantiated to ensure the work of the dryer during the day:

$$V_p^{sw} = \bar{M}[Q_{ZTKj}^{sw}] - W_{OPZm}^g \times \bar{M}[t_{ij}^{sw}]. \quad (5)$$

It should be noted that the capacity  $V_p^{sw}$  is part of the capacity  $V_{pi}$ , because the wet grain is temporarily stored there before it is cleaned up, and then it goes directly to the grain dryer.

To substantiate the capacity of the reserve volume of the item as a whole, it is necessary to compare certain capacities of the variants of the technical equipment P OPZ and the justified variants of the capacity between them will be sought by the capacity of the reserve volume P OPZ, and the set of parameters of each variant of the technical equipment of the subsystems will be parameters of the variant of the technical equipment of the item (Table).

Table. Justification options technical equipment item postharvest processing of grain

№	Subsystem pre-cleaning of grain		Subsystem grain drying		Necessary reserve volume P OPZ, t	Variant of technical equipment P OPZ
	Productivity of the machine for pre-cleaning the grain	Required reserve capacity, t	Productivity of the dryer	Required reserve capacity, t		
1	$W_{OPZ1}$	$V_{p1}$	$W_{ZS1}$	$V_{p1}^{sw}$	$V_{p1} < V_{p1}^{sw}$	$W_{OPZ1}; V_{p1}^{sw}; W_{ZS1}$
2	$W_{OPZ2}$	$V_{p2}$	$W_{ZS2}$	$V_{p2}^{sw}$	$V_{p2} < V_{p2}^{sw}$	$W_{OPZ2}; V_{p2}^{sw}; W_{ZS2}$
...						
m	$W_{OPZm}$	$V_{pm}$	$W_{ZSm}$	$V_{pm}^{sw}$	$V_{p3} < V_{p3}^{sw}$	$W_{OPZm}; V_{pm}^{sw}; W_{ZSm}$

### 4. Conclusion

Rationale parameters equipping items postharvest processing of grain should be carried out in four stages: first rationale set the best options of technical equipment subsystem pre-cleaning of grain for a given production plan and options harvesting-transport complex management; second - justification subsystem grain drying parameters for each subsystem variant of equipping its previous purification; third - support capacity backup volume for each variant of technical equipment subsystems preliminary cleaning and drying of grain justifying the capacity reserve volume, ensuring the functioning of both subsystems; four - definition of rational option equipping paragraph postharvest processing of grain for the whole criterion of minimum total unit cost of funds for post-harvest processing of grain.

The method of justification rationale parameters equipping items postharvest processing of grain is based on the statistical simulation modeling processes of collection and post-harvest grain handling system and allows you to take into account the variability of grain flow characteristics over a day caused by the characteristics and parameters grainplants fields agrometeorological conditions combine period parameters harvesting and transport systems and organizational mode of use, and also the reverse effect processes post-harvest grain handling performance.

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