DETERMINATION OF OPTIMUM OPERATING MODES OF MTA FOR APPLICATION OF FERTILIZERS

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Abstract. *Depending on the utilization factor of the shift time, a sequence is given for optimizing the operational parameters and operating modes of the MTA for applying fertilizers. At the same time, the various operating conditions of its operation are taken into account and options for combinations of operational parameters and operation modes of the MTA are drawn up. As a result of the optimization search, their values are determined according to the criterion of minimizing the reduced costs. On the basis of which the economic efficiency of MTA is compared.*

Keywords: *productivity, shift time, tractors and machines, quality, technological process, loading, speed, maneuver, loading, load capacity, capacity, cycle, timing, run length, parameters, modes, optimality criteria, costs, forecasting.*

INTRODUCTION

As is known, the productivity of the unit is greatly influenced by the shift time utilization factor, which is a significant reserve for increasing the productivity of the MTA.
The shift time utilization coefficient is determined from the relation

$$\tau = \frac{T_p}{T_{\text{см}}} \text{ ч} \qquad (1)$$

where
T_p- clean work time;
$T_{\text{см}}$- Time of change.
Magnitude
$T_{\text{см}}$- depends on the following factors:

$$T_{\text{см}} = T_p + T_{n\text{з}} + T_{\text{пмк}} + T_{\text{от}} + T_{\text{ом}} + T_{\text{отд}} + T_{\text{К}} + T_{\text{отсх}} + T_{\text{пов}} + T_{\text{з}}, \quad (2)$$

where
$T_{n\text{з}}$- preparatory and final time (acceptance and delivery of the unit, placement at the parking site);
$T_{\text{пк}}$- time for moving at the beginning and end of the shift;
$T_{\text{от}}, T_{\text{ом}}$ - accordingly, the time for daily tractor maintenance
and cars;
$T_{\text{отд}}$- time for rest and personal needs;
$T_{\text{к}}$ - quality control time;
$T_{\text{отс}}$ - stop time due to unexpected violation
technological process (cleaning working parts, etc.);
$T_{\text{пов}}$- time to turn;
$T_{\text{з}}$- loading time.
Let's take a closer look at the components of shift time balance.
$T_{\text{нз}}$ - accepted in accordance with standard [I] (for seven-hour
shifts
$T_{n\text{з}}$=0.2 h,

$\boldsymbol{T}_{\text{пмк}}$- is determined taking into account the location of the MTA parking lot from the fertilizer loading point and the speed of the unit:

$$\boldsymbol{T}_{\text{пмк}}=\frac{\boldsymbol{S\partial\cdot n}\cdot 3}{\boldsymbol{V_x}} \qquad (3)$$

where

$\boldsymbol{S\partial\cdot n\cdot 3}$ - distance from the MTA parking lot to the fertilizer loading point, m;

$V_x -$ speed of movement of the unit without load on the road, m/s.

Time for daily maintenance of tractor and machine

$T_{\text{от}}, T_{\text{ом}}$, rest $T_{\text{отд}}$ quality checks $T_{\text{к}}$ stops $T_{\text{ост}}$ normalized [1,4].

Loading time $T_{\text{з}}$ unit includes time for maneuvering and waiting for the tank to be loaded $t_{\text{ож}}$ and loading time of the fertilizer application machine $t_{\text{п}}$

The loading time of the machine for applying fertilizers is determined from the ratio

$$t_{\text{п}}=\frac{Q_m\cdot\alpha_{\text{гс}}}{W_{\text{п}}}, \qquad (4)$$

where

$Q_m -$ load capacity of the fertilizer application machine, kg:

$\alpha_{\text{гс}} -$ statistical utilization rate

lifting capacity;

$W_{\text{п}} -$ hourly productivity of the loader, kg/h.

The time spent on performing one cycle of the fertilizer application operation consists of the following components:

$$t_{\text{ц}} = t_{\text{дг}} + t_{\text{дх}} + t_{\text{ву}} + t_{\text{н}} + t_{\text{тож}} + t_{\text{пов}} \qquad (5)$$

The time spent moving from the loading site to the application site and back is defined as

$$t_{\text{дг}} = \frac{S_{\text{р}}}{V_{\text{г}}}, \qquad (6)$$

$$t_{\text{дх}} = \frac{S_{\text{х}}}{V_{\text{х}}}, \qquad (7)$$

where

$V_{\text{р}}, V_{\text{х}}$ - respectively, the speed of movement of the MTA with a load from the place of loading of fertilizers to the place of application and without a load back, m/s;

$S_{\text{р}}, S_{\text{х}} -$ respectively, the distance from the loading point to the application point and back, m.

The time for applying fertilizer is determined as

$$t_{\text{ву}}=\frac{Q_{\text{м}}\cdot\alpha_{\text{гс}}\cdot 10^{-4}}{D\cdot \text{В}_{\text{р}}\cdot V_{\text{р}}}, \qquad (8)$$

where

$Q_{\text{м}}$ - machine load capacity, kg;

D - fertilizer dose, kg/ha;

$\text{В}_{\text{р}}$ - working width of the unit, m;

$V_{\text{р}} -$ operating speed of the unit, m/s.

Values $Q_{\text{м}}, \text{В}_{\text{р}}, V_{\text{р}}$ are determined based on the equation (I)

In accordance with the restrictions on the quality of fertilizer application and operating modes of the unit. The time for maneuvering and waiting for the tank to be loaded is determined based on the results of timing observations and according to standards [1,4].

The turning time of the unit per cycle is determined as

$$\boldsymbol{t}_{\text{пов}} = \boldsymbol{t'}_{\text{пов}} \cdot \boldsymbol{n}_{\text{пов}}, \qquad (9)$$

where

$t'_{\text{пов}}$ - the time of one turn is determined based on the results of timing observations and normative data [1,4]. Number of turns when applying fertilizers

$$\boldsymbol{n}_{\text{пов}} = \frac{\boldsymbol{Q}_{\text{м}} \cdot \boldsymbol{\alpha}_{\text{гс}} \cdot \mathbf{10^{-4}}}{\boldsymbol{D} \cdot \text{В}_{\text{р}} \cdot \boldsymbol{L}_{\text{р}}} - a, \qquad (10)$$

where

$L_{\text{р}}$ – run length, m;

a - coefficient taking into account the method of movement When applying fertilizers (a=1 with shuttle movement).

The pure operation time of the MTA is determined as

$$T_{\text{р}} = t_{\text{ву}} \cdot n_{\text{ц}}, \qquad (11)$$

where

$n_{\text{ц}}$ – number of MTA operation cycles per shift.

The number of application cycles is determined by the following formula:

$$n_{\text{ц}} = \frac{T_{\text{см}} - T_{\text{пз}} - T_{\text{мнк}} - T_{\text{от}} - T_{\text{ом}} - T_{\text{отд}}}{t_{\text{ц}} + T_{\text{к}} + T_{\text{о.тех}}}. \qquad (12)$$

When searching for optimal operating parameters and operating modes of the MTA, various operating conditions are taken into account, in particular, the distance from the place where the machine is loaded with fertilizers to the place where they are applied $S_{\text{р}}$, $S_{\text{х}}$ - headland length $L_{\text{р}}$ soil background.

CONCLUSION

For each studied variant of combinations of operational parameters and MTA operating modes, the values of the optimality criterion are determined in the specified sequence. For the specific operating conditions of the MTA under study, based on the results of the optimization search, optimal ratios of operational parameters and operating modes are established that ensure minimization of the reduced costs.

Comparisons of the economic efficiency of units with various operating parameters are made using a system of specific indicators.

Increased unit performance:

$$\Pi_w = \frac{W_{\text{см}i} - W_{\text{см}1}}{W_{\text{см}i}} \cdot 100\% \qquad (13)$$

Reduced levelized costs:

$$\text{С}_{\text{н}} = \frac{\Pi_1 - \Pi_i}{\Pi_1} \cdot 100\% \qquad (14)$$

A comprehensive comparison of all economic indicators - MTA allows you to most fully assess the advantage of the option that is specified from the research.

The economic effect of introducing MTA for applying fertilizers with optimal operating parameters is determined as

$$\text{Э}_{\text{г}} = (\Pi_i - \Pi_1) \cdot W_i \cdot \text{З}_{\text{а}}, \qquad (15)$$

where

$\text{З}_{\text{а}}$ – annual unit load, h.

Optimization search based on the selected criterion and the described methodology using multivariate modeling allows solving the problem of predicting the optimal operational parameters of the MTA with high accuracy.

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