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MODELS OF CAR-TRACTOR AGGREGATE PERFORMANCE

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Abstract

First of all, we introduce the following definitions [1-3].

Description. The machine-tractor assembly (MTA) is a mechanical system consisting of working machines, power source (engine), transmission (tractor transmission) and auxiliary (trailers, suspension devices, etc.) mechanisms.

Machine-tractor units are the basis of mechanization of agricultural production. They are evaluated using a number of performance indicators.

Aggregate productivity is one of the main indicators that determine the efficiency of the use of machinery in agriculture.

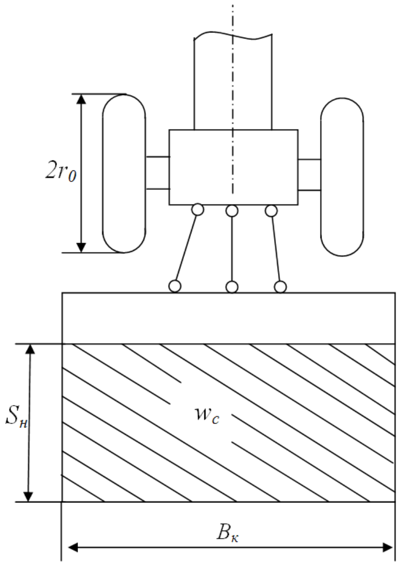
Description. The work output of the aggregate is the amount of work performed by it during a certain period of time and which meets the agrotechnical or zootechnical requirements.

The issue of studying work productivity is of theoretical and practical importance. Theoretical studies of aggregates performance play an important role in determining their performance standards and fuel consumption. Practical study of work productivity - analysis of the factors influencing this indicator, allows to give recommendations based on the selection of optimal factors to scientists, designers, machine-building enterprises and machine testing engineers [4, 5].

The unit's work per hour, shift, day and season is expressed in surface (ha, m ^{2}), volume (l, m ^{3}) and mass (kg, ts, t) units.

In the theory and practice of MTA, hourly net, hourly theoretical, shift, technical and actual (operational) productivity of the unit is used.

Net theoretical efficiency of the unit. Let us assume that an aggregate of non-deformable wheel radius r_0 (m) and structural width $B_к$ (m) moves in a straight line on a solid surface support plane (Fig).



MTA net hourly labor productivity calculation scheme

In this case, its second theoretical work output (m ² /s) or $B_к$ the face of a rectangle with sides and : $S_н$

$$w_c = B_к \frac{S_H}{t} = B_к \frac{2\pi r_0 n_г}{t} = B_к V_H, \qquad (1)$$

where $S_н = 2\pi r_0 \; n_g{}'$ is the theoretical length of the working path, m; t - movement time, s; $n_g{}'$ is the number of rotations of the wheel t in time; $V_н$ - theoretical speed of the unit, m/s.

w_c scaling [ha/h] :

$$w_c = B_к V_н \frac{[м^2]}{[c]} = B_к V_н \frac{10^{-4}[га]}{[coam]/3600} \Rightarrow$$

$$w_c = 0{,}36 B_к V_н [\frac{га}{coam}], \qquad (2)$$

in which $B_к \; [м]$, $V_н \; [м/c]$.

In practical calculations, $V_н \; [км/coam]$ size is mainly used. Therefore

$$w_c = B_к V_н [м] \frac{[км]}{[coam]}. \Rightarrow w_c = B_к V_н [м] \frac{1000[м]}{[coam]} \cdot \frac{10}{10}. \Rightarrow$$

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$$w_c = B_к V_н \frac{[10000\ м^2]}{10[соат]}. \Rightarrow w_c = 0{,}1\ B_к V_н [\frac{га}{соат}], \qquad (3)$$

in which $B_к\ [м]$, $V_н\ [км/соат]$.

It is worth noting that the hourly net theoretical work output of the aggregate is necessary only for a deeper understanding of the physical meaning of the concept of "MTA work output".

Unit shift efficiency. We write the formulas (2) and (3) as follows, denoting the standard duration of the working time of one shift $T_{см}$ with the symbol .

$$w_{см} = 0{,}36\ B_к V_н [\frac{га}{соат}] T_{см} [соат]. \Rightarrow w_{см} = 0{,}36\ B_к V_н T_{см} [га], \qquad (4)$$

where - the standard duration of one shift, hours ($T_{см}$ taken as hours $B_к\ [м]$ for calculations of MTA (machines) performing field work [6]); $T_{см} = 7$, $V_н\ [м/с]$;

$$w_{см} = 0{,}1\ B_к V_н [\frac{га}{соат}] T_{см} [соат]. \Rightarrow w_{см} = 0{,}1\ B_к V_н T_{см} [га], \qquad (5)$$

in which $B_к\ [м]$, $V_н\ [км/соат]$.

Technical performance of the unit. Such performance takes into account the change in the coverage width and movement speed of the unit performing a specific technological operation.

working (actual) $B_и$ and constructive $B_к$ coverage widths there is the following relationship:

$$B_и = B_к \beta; \qquad (6)$$

$$\beta = \frac{B_и}{B_к}, \qquad (7)$$

where β - coefficient of use of the aggregate's constructive coverage width.

In practice, it is difficult to fully use the aggregate's constructive $B_к$ coverage width. Reasons for its underuse [7]:

1) improper management of the aggregate - causes additional coverage of the processed area or its part remains;

2) incorrect construction of the unit - for example, the power of the selected tractor is not enough to operate a comprehensive machine;

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3) incorrect adjustment of machine parts - for example, if the plug housings are not set correctly relative to each other and to the frame, the width of the coverage is impaired;

4) $B_к$ underutilization of coverage width - sometimes when harvesting high-yielding grain with "Case" combines, the operator leaves a part of the field empty.

When calculating the work output of aggregates β are: for trailer plows – 1.10; for hanging plugs – $1{,}03 \div 1{,}07$; for gears - $0{,}95 \div 0{,}98$; for cultivators who till the soil - $0{,}96 \div 0{,}98$; for all types of seeders – 1.0; for silage harvesters – $0{,}95 \div 1{,}0$; for corn combines – 1.0.

It is known that any aggregate $V_и$ moves at a working speed corresponding to this operation when performing a certain technological operation. Its values $V_н$ differ from the theoretical speed under the influence of the following factors [7]:

1) deceleration of tractor drives (wheel, chain);

2) a forced reduction in the rotation frequency of the wheels (stars) due to changes in the loading values falling on the machine (moisture, hardness and density of the soil; the size of the field, the slope; the fluctuation of the yield of crops across the field, etc.);

3) change of wheel dynamic $r_д$ radius (due to deformation of tires, different bearing capacity of soil).

The effect of these factors is the speed utilization η coefficient

$$\eta = V_и / V_н \qquad (8)$$

is taken into account using

From (8): $$V_и = V_н \eta . \qquad (9)$$

The net (useful) operating time of the unit $T_и$ is always smaller than the shift time ( ). $T_{см}$ During mechanized operations, $T_{см}$ some time is spent entering and exiting the field, turning, refueling the machine with fuel, fertilizer or seed, troubleshooting, maintenance, and other stops.

The level of time utilization τ is estimated by the coefficient of utilization of shift time:

$$\tau = \frac{T_и}{T_{см}} . \qquad (10)$$

From (10) $$T_и = T_{см} \tau . \qquad (11)$$

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$V_н$ and $T_{см}$ in formulas (4) and (5) we write the quantities $B_к$, $V_и$ and , $T_и$ respectively , $B_и$ we get the technical or computational work output per hectare . w_T (4) from $w_T = 0{,}36\, B_и V_и T_и$.

Considering equations (6), (9) and (11),

$$w_T = 0{,}36 B_к \beta V_н \eta T_{см} \tau \text{ [to]}, \qquad (12)$$

in $B_к[м]$; $V_н[м/c]$ this

From (5). $w_T = 0{,}1\, B_и V_и T_и$. $\Rightarrow$ $w_T = 0{,}1 B_к \beta V_н \eta T_{см} \tau$ [to], (13)

in $B_к[м]$; $V_н[км/соат]$ this

The actual (operational) performance of the unit is determined using the following formula [9]:

$$w_{эк} = w_0 K_{эк}, \qquad (14)$$

where w_0 - unit productivity in 1 hour basic time (ha, t, tkm);

$K_{эк}$ - coefficient of utilization of operational time.

$$w_0 = F / T_0, \qquad (15)$$

where T_0 - the main working time of the aggregate or the time, hours when all the working bodies of the machine are under load; F - T_0 operation of the aggregate over time (ha, t, tkm).

$$K_{эк} = \left(\frac{1}{K_{см}} + \frac{1}{K_8} + \frac{1}{K_9} + \frac{1}{K_{10}} - 3\right)^{-1}; \qquad (16)$$

$$K_{см} = \left(\frac{1}{K_1} + \frac{1}{K_2} + \frac{1}{K_3} + \frac{1}{K_4} + \frac{1}{K_5} + \frac{1}{K_6} + \frac{1}{K_7} - 6\right)^{-1}; \qquad (17)$$

where $K_{см}$ - shift time utilization coefficient;

K_1 - coefficient of working roads;

K_2 - coefficient of technological service;

K_3 - the reliability coefficient of the technological process;

K_4 - coefficient of walks in the state of transport;

K_5 - coefficient of machine preparation;

K_6 - coefficient of regulated expenses of time;

K_7 - coefficient of shift maintenance;

K_8 - coefficient of periodic maintenance;

K_9 - readiness coefficient;

K_{10} - unit change and equipment coefficient;

$K_1 \div K_{10}$ the values of the coefficients are determined based on the results of chronometric experiments during acceptance tests of machines (units).

In general, the following main indicators are determined in the process of acceptance tests of machines:

* aggregate composition;
* shift time development;
* operational time development;
* relative fuel consumption;
* working speed.

Thus, productivity is the main indicator determining the effectiveness of MTAs, and pure theoretical, shift, technical and operational (real) productivity are studied and taken into account in theoretical and experimental studies.

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