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Determination Of The Rational Volume Of An Elastic Container For Raw Cotton

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Abstract: The rational volume of an elastic container for a cotton-harvesting machine in the technology of harvesting, loading–unloading, and transporting cotton by a containerized method should be selected based on the productivity of the machine, the loader, and the transport vehicle, as well as the length of the run of the cotton field.

Keywords: Elastic container, raw cotton, cotton-harvesting machine, loader, tractor train, hourly productivity, cotton density, downtime, shift time utilization factor.

Introduction: For the uninterrupted operation of the cotton-harvesting machine, its productivity must be equal to the productivity of the tractor train.

$$W_{cot} = n_{tr} \cdot W_{tr}, \quad (1)$$

where: W_{cot} – productivity of the cotton-harvesting machine, t/h;

W_{tr} – productivity of one trailer, t/h;

n_{tr} – number of trailers in the tractor train, pcs.

The hourly productivity of the cotton-harvesting machine during shift time is expressed by the following formula:

$$W_{cot} = 0{,}36\mathrm{B}_r \cdot \gamma_{tr} \cdot u_i \cdot \varepsilon \cdot \mu \cdot \tau, \quad (2)$$

The equation implies that this indicator is influenced by the parameters and operating conditions of the cotton-harvesting machine. In containerized cotton harvesting, working conditions are improved by eliminating downtime associated with unloading cotton from the hopper into trailers and forced stops within the field run. The working conditions are reflected by the shift time utilization factor, which characterizes the continuity of the technological process.

The value of the shift time utilization factor, excluding downtime for maintenance, organizational shortcomings, stops due to violations of the technological process, and troubleshooting of the cotton-harvesting machine, can be represented through the cycle time utilization factor, which is determined by the specifics of the containerized harvesting method:

$$\tau = \frac{\mathrm{T}_{tr}}{\mathrm{T}_t} \quad (3)$$

where: T_{tr} – net time spent on harvesting;

T_t – total time for container unloading and empty runs.

$$\mathrm{T}_t = \mathrm{T}_{tr} + \mathrm{T}_r + \mathrm{T}_i + \mathrm{T}_s \quad (4)$$

where: T_r – time spent unloading containers from the reserving device of the cotton-harvesting machine onto the turning strip of the field, h;

T_i – time spent on the machine's idle runs on the turning strip, h;

T_s – time spent replacing filled containers with empty ones, h;

The productivity of the vehicles involved in the container system can be expressed by the following formula:

$$W_{\text{tr}} = \frac{Q \cdot \phi_u}{\text{T}_{\text{tc}}} \quad (5)$$

where: Q – lifting capacity of the tractor train, t; φ_u – load capacity utilization factor; T_{tc} – duration of the transportation technological cycle, h

$$\text{T}_{\text{tc}} = \text{T}_l + \text{T}_f + \text{T}_{t3t1} + \text{T}_{61} + \text{T}_{62} + \text{T}_{t3t2} + \text{T}_r + \text{T}_p + \text{T}_{it} \quad (6)$$

where: T_l - time for loading containers onto the transport vehicle;

T_f - time for traveling from the field to the collection point;

T_{t3t2} - weighing time;

T_{61} - travel time from the scales to the bunker;

T_t - time spent on unloading containers;

T_{62} - time taken to move from the bunker to the scales;

T_{t3t2} - time for weighing the empty vehicle;

T_r - time for refueling with empty containers;

T_p - time for document processing;

T_{it} - idle time.

According to the proposed collection and transportation technology [1], the total volume of the tractor train bodies can be expressed as

$$\gamma_{\text{b}} = \Pi_{\text{tr}} \cdot m \cdot f_c \cdot v_c \quad (7)$$

where: m - number of containers in the body of a single vehicle, pcs;

f_c - container volume utilization factor;

v_c - container volume, m³.

The carrying capacity of vehicles can be expressed as follows:

$$Q_\gamma = \Pi_{\text{tr}} \cdot m \cdot \gamma \cdot f_c \cdot v_c, \quad (8)$$

where: γ - cotton density in the container, kg/m³.

Taking into account expressions (3-8), formula (2) takes the form:

$$0{,}1\text{B}_r \cdot \gamma_{tr} \cdot u_i \cdot \varepsilon \cdot \mu \frac{\text{T}_{tr}}{\text{T}_t} = \frac{n_{\text{tr}} \cdot m \cdot \gamma \cdot f_k \cdot v_c}{\text{T}_{\text{tc}}} \quad (9)$$

From this, the container volume

$$v_c = \frac{10\text{B}_r \cdot \gamma_{tr} \cdot u_i \cdot \varepsilon \cdot \mu \cdot \text{T}_{tr} \cdot \text{T}_{\text{tc}}}{\Pi_{\text{tr}} \cdot m \cdot \gamma \cdot f_c \cdot \text{T}_t} \quad (10)$$

Preliminary calculations, taking into account the existing vehicles, showed that the container volume for a two-row cotton harvester and a tractor train with four trailers, each accommodating eight containers, is v_c = 1,8...2,2 m³.

Based on the conducted analytical studies, the following conclusions have been drawn:

1. Analytical studies have justified the layered compaction method and determined a coefficient that allows increasing the cotton density in the container.

2. The effect of increasing the container height on cotton density has been substantiated, and a coefficient accounting for the elongation of the flexible container has been determined.

3. The stroke of the compactor has been determined. h_c = 0,3...0,4 m.

4. A flexible container intended for containerized harvesting of raw cotton with a diameter of D =1,1-1,2 m, volume V_c = 1,8-2,2 m³.

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