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Reception and Storage of Grain Mixture Generated After the Combines

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Abstract*— The article presents the results of testing seed mix (seed and seed supplements). There are specific requirements for the size of the assembly unit, its acceptance and storage during the operation. Formulas for determining the size of the picker, the storage of seeds, the bunker for the collection of peeled seeds.*

Keywords— Full and incomplete grain, grain mixture, volumetric weight, receiving device, hopper, grain moisture, throughput, weeds, straw impurities, technological process, mixture composition, grinding wall, straw parts, drying unit, drying, sorting, preliminary cleaning, cultivated plants.

1. INTRODUCTION

To calculate the working machines and auxiliary receiving and transporting devices of the grain processing unit, it is necessary to know its volumetric weight and other physical and mechanical properties.
The grain mixture arriving for post-harvest processing consists of wet full and defective grain, crushed wet stems and leaves of cultivated and weed plants, weed seeds and other impurities.

2. MAIN PART

The bulk density of the mixture can be established both by direct measurement and by calculation, knowing the composition of the mixture and the bulk density of the components. Let the composition of the mixture be characterized by the expression

$$m+n+p+q+\ldots+z=1,$$

then we can write:

$$mQ_c + nQ_c + pQ_c + qQ_c \ldots + zQ_c = Q_m + Q_n + Q_p + Q_q \qquad Q_z = Q_c \qquad (1)$$

where is the total weight of the mixture Q_c;

$$Qm = mQ_c$$

$Qn = nQ_c$ и т. д. and so on — the weight of its constituent parts.
If the volumetric weights of the components of the mixture are $Y_{m}, Y_{n}, Y_{P}, Y_{q, \ldots,} Yz$;
then the relation

$$\frac{Q_m}{\lambda_m} + \frac{Q_n}{\lambda_n} + \frac{Q_p}{\lambda_p} + \frac{Q_q}{\lambda_q} + \cdots + \frac{Q_z}{\lambda_z} = \frac{Q_c}{\lambda_c} = V_m + V_n + V_p + V_q + \cdots + V_z = V_c \qquad (2)$$

where V_c— is the volume of the mixture;; $V_{m}, V_n, V_p, V_q, \ldots, V_z$ — is the volume of its constituent parts.
From expressions (1) and (2) we have

$$\frac{Q_c}{\frac{Q_m}{\gamma_m}+\frac{Q_n}{\gamma_n}+\frac{Q_p}{\gamma_p}+\frac{Q_q}{\gamma_q}+...+\frac{Q_z}{\gamma_z}}=\frac{1}{\frac{m}{\gamma_m}+\frac{n}{\gamma_n}+\frac{p}{\gamma_p}+\frac{q}{\gamma_q}+...+\frac{z}{\gamma_z}}=$$

$$=\frac{\gamma_m\gamma_n\gamma_p\gamma_q...\gamma_z}{m(\gamma_m\gamma_n\gamma_p\gamma_q...\gamma_z)+n(\gamma_m\gamma_n\gamma_p\gamma_q...\gamma_z)+...+z(\gamma_m\gamma_n\gamma_p\gamma_q...\gamma_z-1)},\ m/м^3 \quad (3)$$

Since the grain mixture mainly consists of grain and crushed strawy parts, then for approximate calculations VG Antipin [1] proposed the following expression

$$\gamma_c=\frac{\gamma_{z-1}}{(1-z)\gamma_z+Z\gamma_{z-1}},\ m/м^3 \quad (4)$$

where is the volumetric weight of grain γ_{z-1}, $m/м^3$; γ_z — bulk density of impurities, , $m/м^3$, z- content of impurities in the mixture in fractions of a unit; (1-z) - grain content in the mixture in fractions of a unit.

The volumetric weight of a grain changes depending on its moisture content. So, for example, if at a grain moisture content of 15% the bulk density is 0.775 t / m^3 for wheat, then at a moisture content of 25% the bulk density is 0.675 t / m^3. The volumetric weight of the crushed strawy parts varies within the limits, depending on the degree of crushing, moisture, compaction, etc.

On average, for approximate calculations, y_z = 0.050kg / m^3 can be considered.

Determining, for example, the bulk density of the grain mixture when harvesting wheat with a grain moisture of 25% and the content of straw impurities z = 0.10, we obtain

$$\gamma_c\approx\frac{0,420\cdot 0,050}{(1-0,10)\cdot 0,050+0,10\cdot 0,420}\approx 0,250,\quad m/м^3$$

Due to the compaction of the straw parts with grain, the actual value of the bulk density will be slightly higher than the calculated one. The volumetric weight of the grain mixture must be taken into account not only when designing units for processing grain, but also when determining the capacity and calculating vehicles delivering the grain mixture from the combines.

In the unit for post-harvest grain processing, devices are required for receiving the incoming grain mixture, collecting and temporarily storing it after preliminary cleaning before drying, storing grain after primary drying, collecting dry clean grain after final cleaning and sorting, etc.

The capacity of these devices must ensure the reception of the grain mixture and the uninterrupted operation of the unit for its completion. The capacity must be determined taking into account the amount, volumetric weight and other properties of the grain mixture, in relation to the established technological process of its refinement.

The capacity of the receiving device is determined by the amount of grain mixture delivered at the same time. With the full use of the carrying capacity and the minimum volumetric weight of the grain mixture delivered by one car, the volume of the mixture is

$$V_a=\frac{Q_a}{\lambda_c},\ м^3$$

Considering that each time the working harvesters are served by one car, the total capacity of the receiving device for the grain mixture delivered from the field with simultaneous unloading of cars should be taken equal to

$$V_1 = n_k Va = n_k \frac{Q_a}{\lambda_c}, м^3, \quad (5)$$

where n_k - the number of harvester units serviced; Q_a - carrying capacity of the vehicle, t; λ_c - volumetric weight of the grain mixture.

In fact, this capacity can be somewhat reduced, taking into account that simultaneous unloading of machines is impossible and in the interval between unloading of two vehicles part of the grain mixture from the receiver will be fed for revision. The minimum capacity of the receiving device proposed by M.P. Gorbunov [2]) must be at least the capacity of the body of one car, i.e.

$$V_1 \geq V_a \frac{Q_a}{\lambda_c}, M^3$$

The capacity V_2 of the collecting device for grain obtained after preliminary processing of the grain mixture can be determined from the following expression:

$$V_2 = \frac{Q_c \alpha_1}{\gamma_c \alpha_2} - \frac{P_2 t_k \eta_c}{\gamma_c \eta_k} - V_c, \quad (6)$$

where Q_c — is the weight of the grain mixture delivered per day, t; α_1, α_2 - grain content in the mixture before preliminary cleaning and after cleaning in unit fractions; γ_c - volumetric weight of the grain mixture after preliminary cleaning, t / m3,

P_2 - throughput of the drying part of the unit, m / h;

t_k - is the number of hours of clean work of combines; η_k - coefficient of using time for clean work of combines; η_c time utilization rate for clean operation of the dryer;

V_c - grain capacity of the drying part of the unit, m^3.

Replacing Qc and P_2 in expression (6) with their values from the corresponding equations, we can write

$$V_2 = \frac{\Omega_a Q_o (100 - W_k)\left(1 - \frac{t_k \eta_c}{\eta_k t_c}\right)}{10 T \alpha \eta_T (100 - W_o) \lambda_c \alpha_2} - V_c, м^3, \quad (7)$$

The capacity V3 of the grain storage bin should be sufficient to receive all the grain processed by the unit per day minus the grain that is being dried, i.e.

$$V_3 = \frac{Q_c \alpha_1 (100 - W_o)\left(1 - \frac{t_k \eta_c}{\eta_k t_c}\right)}{10 T \alpha \eta_T (100 - W_k) \lambda_c \alpha_2} - V_c, \quad м^3, \quad (8)$$

where γ_c - is the volumetric weight of grain after preliminary drying, t / m3; α_2 - the content of grain in the mixture after preliminary drying in unit fractions;

W_0— grain moisture before drying, %;

W_K- is the moisture content of grain after preliminary drying, %

Q_c Substituting its value instead, we get,

$$V_3 = \frac{\Omega_a Q_o \alpha_1 (100 - W_o)}{10 T \alpha \eta_T \alpha_2 (100 - W_k) \gamma_c} - V_c, м^3 \quad (9)$$

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The capacity V_h of collecting bins for dry clean grain can be taken from the condition

$$\frac{Q_a}{\gamma_o} \langle V_h \langle \frac{Q_c \alpha_1 (100 - W_o)}{\gamma_c (100 - W_k)}, \quad м^3, \tag{10}$$

where Q_a is the carrying capacity of the vehicle, which transports the grain, t; λ_o - the minimum volumetric weight of grain, t / m3; Q_c - weight of the grain mixture arriving for processing per day, t; α_1 - grain content in the grain mixture before processing in unit fractions; W_o and W_k are the initial and final moisture content of the grain.

Replacing Qc with its value, we can write

$$\frac{Q_a}{\lambda_o} \langle V_h \langle \frac{\Omega \alpha Q_o}{10 T_a \eta_T \lambda_o - W_k}, M^3 \tag{11}$$

Let us determine the capacity of the receiver for the pre-cleaned grain mixture and the capacity of the hopper for storing grain when harvesting wheat.

Let λ_c = 0.4 t / m3, η_k = 0.6, η_c - 0.9 and V_c = 10.8 m3 (three dryers with P_2 = 1.2 t / h at W_y = 6%) and substituting these data into expression (7) , we obtain the capacity of the receiver of pre-cleaned grain:

$$V_2 = \frac{300 \cdot 0,325 \cdot 20 \left(1 - \frac{6 \cdot 0,9}{0,6 \cdot 21}\right)}{10 \cdot 8 (100 - 25) 0,4 \cdot 0,98} - 10,8 \approx 30 м^3$$

The capacity of the hopper for storing grain with the grain content in the pre-dried mixturev α_2 = 0.99, its bulk density λ_2 = 0.50 t / m^3 and grain moisture W_k = 20% in this example, according to expression (9)

$$V_3 = \frac{300 \cdot 0,325 \cdot 20 (100 - 15)}{10 \cdot 8 \cdot 0,99 (100 - 20) \cdot 0,50} - 10,8 \approx 40 м^3$$

If, in this example, the grain that is in the storage is to be scattered in a layer 0.25 m thick, then an area of 40: 0.25 = 160 m will be required. In the case of storing grain in a multi-section bunker, the required area is significantly reduced. Putting the useful height of the bunker sections equal to 3 m, and their length 2.5 m with a grain layer thickness of 0.375 m in the section, the number of bunker sections will be

$$i^3 = \frac{V_3}{\Delta V_3} = \frac{40}{3 \cdot 2,5 \cdot 0,375} = 10,8. \qquad \text{Take } i^3 = 14.$$

If the air gap between the sections is 0.25 m, the area required for the bunker will be

$$F_3 = i_3 \Delta F_3 = 14 \cdot 2,5 (0,375 + 0,250) = 22 м^3$$

3. Conclusion

Thus:

1. With the use of a multi-section bunker, the area required for grain storage is reduced by almost 8 times.

2. The proposed methods for determining the main indicators and calculating aggregates for grain processing is only a first approximation and are subject to further development, verification and refinement.

3. These methods can be useful both in the design of working machines and in the development of auxiliary receiving and transporting devices in mechanized units for post-harvest grain processing in Uzbekistan.

4. REFERENCES

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