The results of experimental studies of the working body of the loader pile of fodder crops

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Abstract. The article substantiates the need for this study, analyzes the advantages and disadvantages of various working bodies of loading devices, as well as the results of the analysis on the prospects of a finger-type separating working body for uniform loading of a pile of seeds into dryers. The factors influencing the working process of leveling the material and the methodology of experimental research are given. The maximum number of factors influencing the process under study has been determined, the most likely areas of their change have been selected and the conditions characterizing the process of leveling the pile of fodder crops by the loader have been selected. The schemes of dependence of the coefficient of uneven leveling of the pile on the feed rate of the material and the speed of rotation of the drum, the dependence of uneven leveling on the length of the finger and the gap between them, the dependence of uneven leveling on the diameter of the drum and the number of rakes and the dependence of uneven leveling on the angle of the fingers and the thickness of the layer of the pile, as well as the influence of kinematic, structural and technological parameters of the working body are presented on the quality of leveling the pile.

Keywords: experiment, methodology, research, kinematics, design, factor, justification, loader, working organ, finger drum, coefficient of unevenness, dependence, alignment, heap of fodder crops, feed rate, rotation speed, diameter.

1 Introduction

One of the important directions in the Action Strategies for the five priority areas of development of the Republic of Uzbekistan in 2017-2021 is the modernization and intensive development of agriculture, that is, the dynamic development of agricultural production, the optimization of acreage for fodder crops, the introduction of high-performance and resource-saving agricultural technologies and agricultural machinery.

The main reason for the successful development of animal husbandry is the creation of a solid fodder base for intensively developing animal husbandry.

In the general package of measures to solve the problem of creating a solid fodder base for intensively developing livestock, as indicated in the resolutions of the President and the Government of the Republic of Uzbekistan, is the expansion of crops and a

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significant increase in the production of feed from crops with a high protein content (protein) [1, 4].

In the Republic, the sowing of perennial grasses for seeds does not fully satisfy the need of farms for seeds of fodder crops. For example, most varieties of cereals, legumes, oilseeds and fodder crops are still imported from Russia. Seed production is the most important factor in the development of agriculture. The production of seeds of high-yielding varieties is very important for obtaining a high yield and improving the quality of agricultural products.

The period of harvesting herbs for seeds, as a rule, coincides with bad weather conditions. It is possible to get rid of the dependence of adverse weather conditions by introducing the technology of harvesting fodder crops for seeds by the method of combing heads and leaf parts on the root. The most important condition for the successful use of drying plants is to ensure high-quality alignment of the material layer on the dryer conveyor [1, 3, 15].

In this regard, research was conducted to study the working process of loading a seed pile of agricultural fodder crops on conveyor-type dryers.

2 Materials and methods

Theoretical studies have established that in order to substantiate the main parameters of the loader's working bodies, it is necessary to analyze the advantages and disadvantages of various working bodies of loading devices. As a result of the analysis, a hypothesis was put forward about the prospects of a finger working organ of a separating type for uniform loading of a pile of seeds into dryers. However, in order to widely introduce the proposed working body into production, special research is needed, since there are no recommendations in the literature for their calculation and design. In the study of any process, all possible factors that determine the course of the process should be identified, no matter how large their number is. The main condition determining the most correspondence of the real physical picture of the studied process to its mathematical description is taking into account all the main factors affecting the process and the areas of their change. At the same time, they must comply with the actual conditions of the process under study, taking into account ensuring the operability of the structure and the possibility of constructive execution of the working body. [5,7,8].

Therefore, based on the objectives of the study, it is necessary to determine the largest possible number of factors affecting the process under study, to select the most likely areas of their change, which characterize the conditions of the process of leveling the pile by the loader of conveyor-type dryers.

To study the design schemes of finger drums, the following factors were identified: the diameter of the drum, the length of the fingers, the gap between the fingers, the angle of inclination of the fingers, the frequency of rotation of the drum, the speed of the feeding conveyor, the number of combs, the thickness of the pile layer.

The exploratory studies were carried out according to the scheme of a one-factor experiment for the entire group of factors affecting the working process of leveling the material. The method of conducting experiments is as follows. In the initial state, all the studied factors were fixed at levels corresponding to the average value of the area of their change. To conduct the experiment, a factor was randomly selected and its effect on the optimization parameter within the boundaries of the definition domain was investigated. After the end of the experiment, this factor was fixed at the level corresponding to the value of the optimization parameters.

In accordance with the recommendations [10, 11, 12], the experiments were carried out in fourfold repetition, which corresponds to a confidence probability with a level of

0.95 and an experimental accuracy of 2%. The criteria by which the working body was evaluated was the coefficient of uneven leveling of the pile.

3 Results and Discussions

The analysis of the existing designs of the working bodies of the loading devices allowed us to establish the prospects of using finger working bodies of the separating type. However, in order to widely introduce the proposed working body into production, special research is needed. The dependences of the uneven leveling on the feed rate of the material and the rotation frequency of the drum are shown in Fig.1.

It can be seen from the figure that with an increase in the feed rate of the material (the speed of the feeding conveyor) from 5.5. 10-3 to 7.5. 10-3 m / s, the coefficient of unevenness increases from 17.1 to 25.4%, since with an increase in the feed rate, the fingers of the working organ (drum) penetrate deeper into the mass of the pile and pick up large portions of material from the bottom up. In addition, the area of capturing the mass of the pile with one rake increases. At the same time, as it is established, the fingers do not have time to capture the entire incoming pile, as a result of which the pile is compacted at the drum and periodically captured in large portions. All this leads to an increase in the load on the fingers, to a deterioration in the process of separating the pile from the bulk and an increase in the energy intensity of the process (loading) of leveling the material. The optimal feed rate of the material (feed conveyor) can be taken in the range of 3.5.10-3 to 5.5.10-3 m/s. At the same time, the value of the coefficient of unevenness is 17.0% [1, 6, 9,].

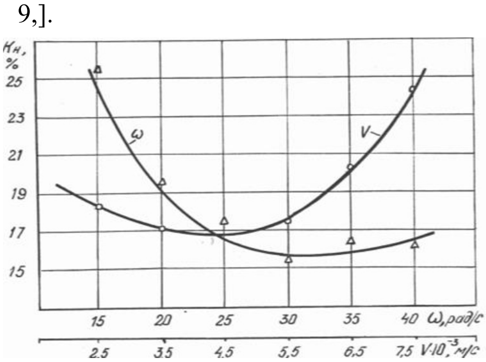

Fig. 1. The dependence of the unevenness of leveling on the rotation frequency of the drum ω and the feed rate of the material V

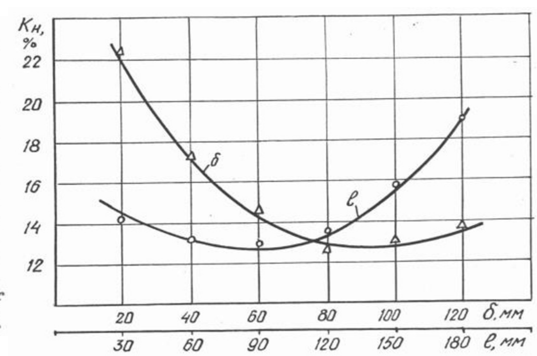

Fig. 2. The dependence of the unevenness of leveling on the length of the finger ℓ and the gap between them δ

The results of the study of the dependence of the optimization parameter on the rotation frequency of the drum are shown in Fig.1. An increase in the speed of rotation of the drum leads to an improvement in the indicators of uneven leveling. The unevenness decreases from 24.8 at ω = 15 rad /s to 15.9% at ω = 35 rad / s, This is due to the fact that the amount of finger insertion into the mass decreases, as well as the size of the mass capture zone of the pile with one rake decreases and inertial forces increase, which play an important role in the process of separating the particles of the pile from the total mass.At the same time, the descent of the material from the fingers of the rake improves, each comb captures and separates a portion of the pile more evenly [14, 16, 18].

Due to the large inertia of the mass and the short-term action of the fingers on the material, breakouts of increased portions are not observed. Only the part of the pile that was directly in the area of the fingers is separated. At a rotational speed of ω = 25 rad / s or less, an intensive increase in the coefficient of uneven leveling is observed due to the large supply of the pile to the finger.The pile is separated in enlarged portions.

As can be seen from Fig. 1. The most acceptable value of the drum rotation speed is within ω = 25 ... 35 rad / s, which corresponds to the minimum values of unevenness. From the graph Fig.1. it can also be seen that the factors V and ω are interrelated.

With a decrease in the feed rate V and an increase in the rotational speed ω, the coefficient of unevenness decreases, but a decrease in the feed rate of the material has a limit, since at a minimum speed V = 2.5.10-3m / s, with an increase in ω, the unevenness increases.

This phenomenon can be explained by the fact that the supply of material to the finger is too small, as a result of which the captured particle leaves it before it leaves the layer. At V =3.0.10-3, with a decrease in ω, it contributes to a decrease in unevenness, since the grasping ability of the fingers improves.This is consistent with the conclusions of N.I.Volodko, P.K.Zhevlakov, V.Rayevsky and P.I.Moiseev that the rotation frequency of the drum must be changed in accordance with the change in the feed rate of the material.

In this case, this is true within the range of the V change from 3.0. 10-3 to 6.5. 10-3. Above this limit, the Kn value decreases with increasing ω.Thus, at V =3.0.10-3 + 6.5.10-3 m/s, it is advisable to choose ω = 25+35 rad/s.

In Fig.2. the dependence of the uneven leveling of the pile on the length of the fingers and the gap between them is presented. The figure shows that with an increase in the length of the fingers from 30 to 180 mm, the unevenness index gradually decreases at first (in the range of 30 + 90 mm), and then increases. With a finger length of 180 mm, the Kn is 19%.

With a longer length, the fingers can penetrate deeper into the material and pick up large portions of the pile. At the same time, the descent of particles from the long finger worsens due to an increase in the path traversed by particles on the surface of the fingers. As a result, it is possible to throw the material back towards the raw pile array [17, 20, 21].

The best uniformity of laying the pile on the conveyor is achieved when the length of the fingers is within ℓn = 80 ... 100 mm. At the same time, the Kn is 12-13%.

The gap between the fingers (Fig. 2) varied from 20 to 120 mm. As a result of experiments, it was found that with an increase in the gap of more than 100 mm, the value of the unevenness index begins to increase. This is due to the fact that with rarely spaced fingers, the conditions for separating all the piles coming to the drum worsen. Part of it is separated by the fingers with enlarged bundles, and the small pile is not picked up by the fingers, but is separated by the rake bar itself, which leads to an increase in energy intensity due to the friction forces of the bar on the pile. A decrease in the gap of less than 80 mm leads to an increase in the value of the uneven leveling indicator. This happens due to the fact that the pile is picked up by a rake across the entire width of the material without pulling it out in bundles. The smallest value of the unevenness value is obtained when the gap between the fingers is set within 80 +100 mm.

The dependence of the unevenness of leveling on the diameter of the drum and the number of rakes are shown in Fig.3. The graph shows that with an increase in the diameter of the drum from 0.42 to 0.58 and the unevenness decreases from 24.31 to 15.8%. This phenomenon is explained by the fact that as the diameter increases, the angle of rotation of the rake increases. At the same time, the conditions for the entry of fingers into the mass of the pile are improved. However, a further increase in the diameter of the drum leads to an increase in metal consumption, complication of the loader design, etc.

When selecting this parameter, the maximum length of the stems in the pile was also taken into account. In further studies, the value of the drum diameter was equal to D = 0.56 m, at which a good quality of work Kn = 15.0% was ensured. The unevenness with an increase in the number of rakes from 2 to 5 decreases from 22.7 to 13.6%. This is due to a decrease in the mass of the material supplied to one comb, and more frequent stacking of small portions on the dryer conveyor.

With an increase in the number of rakes from 6, the gripping ability of the fingers deteriorates somewhat, especially with an increased speed of rotation of the drum, since in this case the pile may not fall between the rakes, it is not captured by the fingers, but only repels. In addition, with an increase in the number of rakes, difficulties arise in the constructive execution of the working body and its metal consumption increases. With rakes less than four fingers begin to separate the pile in enlarged portions, while in some cases a support is formed by its drum cylinder. Satisfactory unevenness (14.2%) is observed with four rakes. Based on this, for further research, we take the number of rakes Z = 4

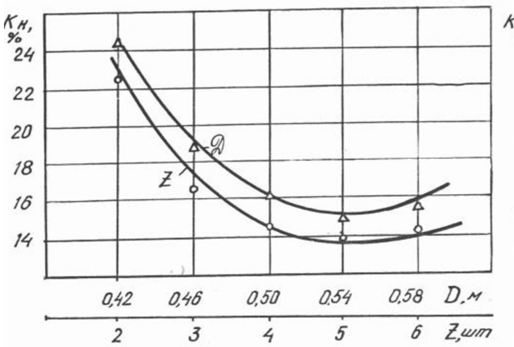

Fig. 3. The dependence of the unevenness of leveling on the diameter of the drum D and the number of rakes Z

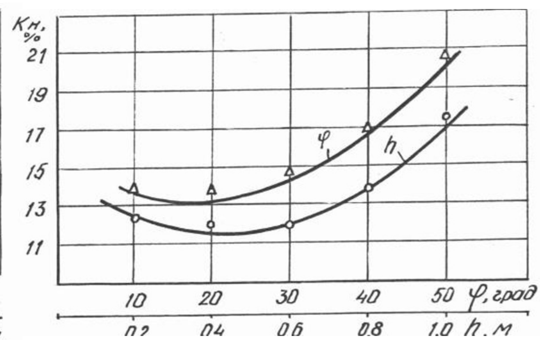

Fig. 4. The dependence of the unevenness of leveling on the angle of installation of the fingers φ and the thickness of the pile layer h

The dependence of the value of the indicator of the unevenness of leveling the angle of installation of fingers and the thickness of the pile layer is shown in Fig.4. during the research, the fingers were installed at an angle from 10 to 50 degrees to the radius. Analysis of the research results shows that with an increase in the angle of inclination relative to the radial position, the value of the unevenness index increases from 13.30 to 20.92% [1, 2].

This is explained by the fact that with an increase in the angle of inclination of the fingers in the direction of rotation, the descent of the heap particles from the fingers of the rake worsens, as a result of which some particles are thrown back, i.e. into the untreated heap array. The smallest value of the optimization parameter is obtained at the angle of inclination of the fingers φ = 10 ... 15o.From the dependencies (Fig.4.) it can be seen that with an increase in the thickness of the pile layer, the unevenness increases, since the pile is scattered in large unbroken lumps due to the collapse of the pile over the drum.In this case, the working body may jam. As the layer thickness decreases below some optimal value, the unevenness also increases. This can be explained by the fact that at the same time, not all the pile captured by the fingers is thrown over the drum, part of it is thrown back. The smallest value of the optimization parameter is obtained with a layer thickness within h = 0.5...0.6 m. [23]

4 Conclusions

The conducted studies have allowed us to establish that the most effective is the finger working organ of the separating type. It has the lowest energy consumption of embedding into the material, since the cross-sectional area of the layer is smaller, and therefore the resistance force to embedding is smaller. They are reliable in operation, less energy-intensive and distribute the material of the required layer thickness evenly over the area. [24] However, in order to widely introduce the proposed working body into production, special research is needed, since there are no recommendations in the literature for their calculation and design. Based on the results of the conducted exploratory laboratory experiments, the following can be accepted as constructive, kinematic parameters and operating modes of the finger drum (working organ): D = 0.52....0.56 m, the number of rakes Z = 4....6 pcs., the length of the fingers ℓn = 0.08... 0.10 m, δ = 0.8 ... 0.10 m, drum rotation frequency ω = 25...35 rad/s finger angle φ = 10o...15o.With these parameters, the feed rate of the material can be selected V = 3.5. 10-3 ... 5.5. 10-3 m / s, and the thickness of the pile layer in front of the drum is within h = 0.5 ... 0.6 m.

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