Improvement of a device for cleaning carrots from soil impurities and plant residues

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Abstract. *A laboratory unit has been developed for cleaning carrots, which will improve the quality of cleaning carrots from soil impurities and plant residues. The proposed design of the device for orienting carrots during cleaning.*
KEYWORDS: *CARROT, ROOT CROPS, CLEANER, LABORATORY EQUIPMENT.*

Introduction

An important problem when harvesting carrots is cleaning the root crops from soil impurities and plant residues.

An important indicator that affects the quality of root crop harvesting machines (beets, carrots) is the depth and location of the fruits relative to the soil surface, as well as their size and weight characteristics.

Due to the fact that the vast majority of carrot root crops have an elongated cylindrical shape and the biological material that forms the carrot itself is very fragile, the technological process of cleaning carrots in the form of a heap is complicated.

The separate method of harvesting carrots requires cleaning the carrots heap removed from the soil from impurities. Various types of cleaners can be used for this purpose. The results of theoretical and experimental studies of the processes of digging up and cleaning sugar beet roots are presented in [1-3].

The most suitable cleaner for carrots from soil impurities and plant residues is a spiral separator. For this purpose, a spiral prototype separator can be used [4]. Experimental studies have shown that this separator provides a fairly high level of cleaning with minimal damage to root crops, which is within the limits of agrotechnical requirements [5, 6]. However, carrots are harvested under conditions that differ from those for potatoes. Therefore, it is necessary to change the technical and technological characteristics of the above-mentioned separator [7].

In addition, existing methods for determining the degree of damage and separation of root crops by machine working parts are labor-intensive and can only be used during the harvest season, which limits the time available for engineers to conduct research aimed at improving the technical level of new machines [8, 9]. Methods that can be used in laboratory conditions do not provide a comprehensive assessment of the functioning of working bodies and machines as a whole and can only be used for a comparative assessment of the degree of damage and separation of root crops [10].

An analysis of known studies has shown that the problem of high-quality cleaning of carrot root crops during their mechanized harvesting has not been fully solved.

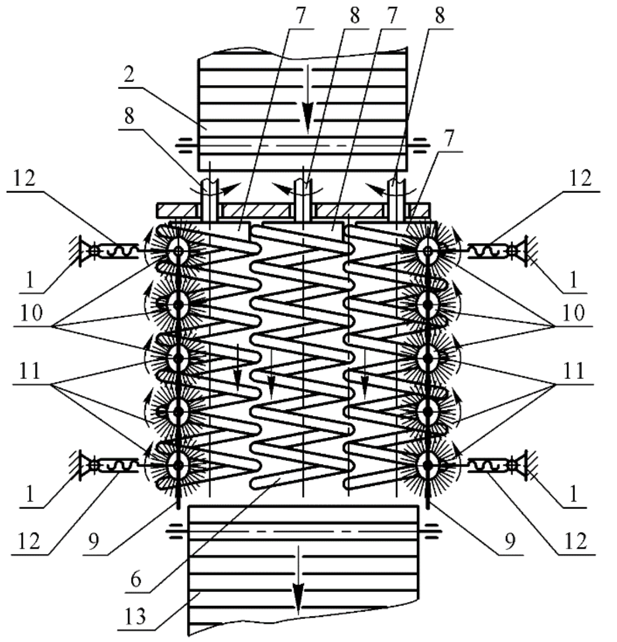
Therefore, the development of a device for cleaning carrot root crops from soil impurities and plant residues is an important and relevant scientific and technical problem in the field of agricultural engineering.

Results and discussion

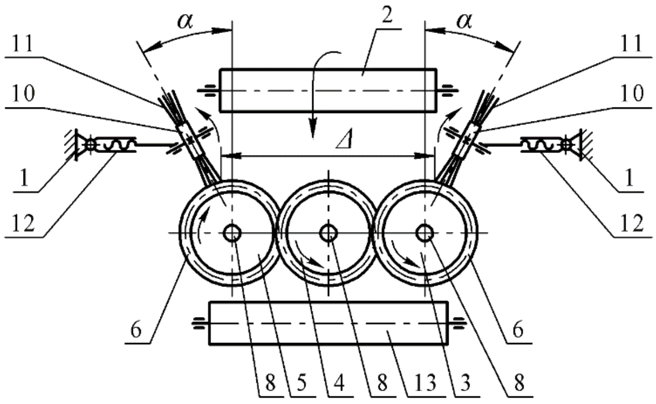
To improve the quality of cleaning root crops of carrots from soil impurities and plant residues, a structural diagram of the device was developed, which is shown in Fig. 1.

Fig. 2 shows a 3D model of a laboratory experimental installation for cleaning root crops of carrots.

The cleaner for root crops from impurities consists of a frame 1, a loading conveyor 2, three sequentially arranged cleaning rollers: 3, 4, and 5, made in the form of cantilever spiral springs 6, installed with one end on hubs 7, connected to drive shafts 8 (drive mechanisms for rotational movement are not shown). The cantilever spiral springs 6 have screw threads directed towards the cantilever ends of the spiral springs 6 and are installed with mutual overlap of the outer parts of their spirals. At the same time, frames 9 are installed on both sides above the cleaning rollers 3 and 5, on which the drive mechanisms (drive mechanisms for rotational movement are not shown) cleaning brushes 10 with short elastic rods 11, the lower ends of which touch the cantilever spiral springs 6 of the cleaning rollers 3 and 5.



a



b

Figure 1. *Design diagram of a device for cleaning carrots from soil impurities and plant residues: a) – general view from above; b) – side view*

In cross section, this forms a trapezoidal cleaning channel above the surface of cleaning rollers 3, 4, and 5, with the upper part facing downwards. The minimum distance from the lower ends of the short elastic rods 11 on both sides, inside the specified cleaning channel, is characterized by a width Δ. At the same time, the ends of the frames 9 on both sides are attached to the mechanisms 12 for their movement and fixation relative to the frame 1, which makes it possible to change the specified width Δ. The end part of the cleaner (i.e., where the free ends of the cantilever spiral springs 6 of the cleaning rollers 3, 4, and 5 are located) has a discharge conveyor 13 installed at the bottom. The directions of rotational and oscillatory movements are shown by arrows.

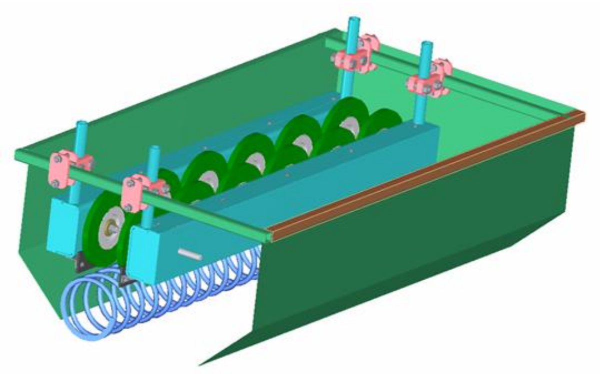


Figure 2. *3D model of a device for cleaning carrots from soil impurities and plant debris*

The root crop cleaner is operated in the following way. The root crop pile is removed from the soil (and therefore contains a lot of soil impurities, rhizomes, and plant residues) is fed by a loading conveyor 2 from above onto a surface formed by cleaning rollers 3, 4, and 5, which are made in the form of cantilever spiral springs 6 that are forcibly rotated in one direction. The root crop heap cleaner works as follows. The root crop heap removed from the soil (and therefore containing a lot of soil impurities, rhizomes, and plant residues) is fed by the loading conveyor 2 from above onto the surface formed by the cleaning rollers 3, 4, and 5, made in the form of cantilever spiral springs 6, which are forced to rotate in one direction. At the same time, the root crop pile is immediately dispersed over this surface and, by the rotating cantilever spiral springs 6, begins to be transported not only in the radial direction, but also in the axial direction of the cantilever spiral springs 6 themselves (i.e., the directions of the coils of the cantilever spiral springs 6 are directed from the hubs 7 to their freely located ends, which ensures the transportation of root crops in the specified direction). Since the cantilever spiral springs 6 have freely positioned ends, it is precisely the oscillation of their free ends in the longitudinal-vertical plane, under the action of an alternating load, that contributes to the effective separation of small soil impurities through the coils of the cantilever spiral springs 6 themselves down beyond the cleaner. In addition, when transported over the specified surface, the bodies of the root crops come into contact with the coils of the cantilever spiral springs 6 of the cleaning rollers 3, 4, and 5 and are thus cleaned of soil adhering to their outer surfaces. Due to the fact that the cleaning rollers 3, 4, and 5, which are made in the form of cantilever spiral springs 6, are installed with mutual overlap, they (cantilever spiral springs 6) are capable of self-cleaning from adhering wet soil during rotation, which significantly improves the quality of cleaning. Due to the fact that frames 9 are installed on both sides above cleaning rollers 3 and 5, on which drive cleaning brushes 10 with short elastic rods 11 are located at the same angles α to the vertical axes of rollers 3 and 5 with the appropriate pitch, all parts of the pile are essentially located inside the cleaning channel in the form of a trapezoid, the upper part of which is directed downward. Since the lower ends of the short elastic rods 11 of each drive cleaning brush 10 touch the cantilever spiral springs 6 of cleaning rollers 3 and 5, the root crops are mainly concentrated in the spaces between 3 and 4 and between 4 and 5 cleaning rollers, where the most intensive cleaning of the root crops from adhering soil takes place. The shortest elastic rods 11, which in each drive cleaning brush 10 have the same directions of rotational movements, which are directed towards the unloading conveyor 13, not only ensure effective capture of small soil impurities and plant residues and their removal beyond the cleaner, but also ensure very efficient transportation of root crops. Due to the angles α to the vertical axes of the rollers 3 and 5 of the drive cleaning brushes 10 with short elastic rods 11, a cleaning channel is formed in the form of a trapezoid, the upper part of which is directed downward. This ensures the conditions under which, in the event of impacts of root crops and their bouncing, they will inevitably be returned to the inside of the cleaning channel, touching only the upper parts of the drive cleaning brushes 10. In addition, the minimum distance from the lower ends of the short elastic rods 11 of the drive cleaning brushes 10 on both sides, which is characterized by the width Δ, can be changed due to the fact that the ends of the frames 9 on both sides are attached to the mechanisms 12 for their movement and fixation relative to the frame 1. This width Δ is minimal, since further reduction will result in the cleaning rollers 3 and 5 being effectively excluded from operation. However, using the mechanisms 12 for movement and fixation, it is possible to move the ends of the frames 9, and accordingly the drive cleaning brushes 10, with their short elastic rods 11 on both sides of the cleaning rollers 3, 4, and 5, thereby increasing the specified width Δ. This will increase the specified cleaning channel, but it is necessary to ensure that the lower ends of the short elastic rods 11 continue to touch the cleaning rollers 3 and 5. Excessive increase in the minimum width Δ will lead to possible loss of small root crops. After complete cleaning, the root crops fall onto the unloading conveyor 13 and are transported outside the cleaner to a hopper or a transport vehicle.

Due to the fact that the vast majority of carrot root crops have the shape of an elongated cylinder and the biological material that forms the carrot itself is very fragile, it is difficult to clean carrots in the form of a heap, since the root crops in the cleaner channel can be placed chaotically. Fig. 3 shows a 3D model of a laboratory setup for orienting carrot roots.

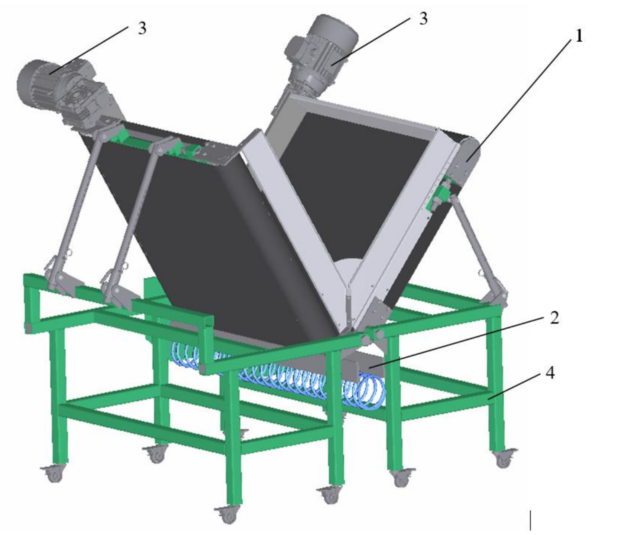


Figure. 3. *3D model of the carrot orienting device:*
1 – inclined conveyor; 2 – transverse conveyor;
3 – electric motor; 4 – frame

To ensure the desired positioning of carrot roots on the surface of the developed cleaner, formed by cleaning rollers made in the form of cantilever spiral springs, a laboratory installation for orienting carrot roots has been developed.

The device for orienting the placement of carrots can be used provided that each root crop must be cleaned individually. In addition, the developed device for orienting carrots can be very useful when the roots removed from the soil need to be placed in containers. If separate harvesting technology is used, then the cleaning process is a mandatory element in carrot harvesting machines.

Conclusions

A laboratory unit for cleaning carrot roots has been developed, which will improve the quality of cleaning carrot roots from soil impurities and plant residues. The proposed design of the device for orienting carrot roots during cleaning. The application of this device will ensure the proper positioning of carrots on the surface of the developed cleaner, formed by cleaning rollers made in the form of cantilever spiral springs. In addition, the developed device for orienting carrots can be very useful when the bodies already removed from the soil need to be placed in containers.

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