Justification of the improved technological process and development of the construction of the cleaner of root tubers from impurities

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Abstract. *The paper presents a new construction of a root ball cleaner from impurities, consisting of five wave-shaped working spirals, which are given oscillatory movements with appropriate amplitudes and frequencies in the longitudinal-vertical plane. It allows to considerably expand a working zone of separation of the potato heap arriving on clearing, and it will promote its better dispersion on a working surface of the cleaner, more intensive destruction of ground clods, and consequently, improvement of sifting of ground and vegetative admixtures and decrease of blocking of working spirals. All this ultimately increases the productivity and quality of the new root crop cleaner from impurities. To carry out experimental studies of the new construction of the cleaner of potato roots from impurities, we have developed a laboratory setup, which allows you to test and justify the basic constructional and kinematic parameters of this cleaner. The process of cleaning of root crops from soil impurities and plant residues indicated cleaner is due to the movement of the heap coils cantilevered spiral springs, which rotate at a certain angular velocity, and the oscillatory motion of the springs themselves, arising from the deflection of their longitudinal axes. In this case, soil and plant impurities are sifted through the separating gaps and coils of spirals, and the bodies of potatoes are transported by coils of spirals in the direction of the unloading conveyor. Calculations of the required power for the drive of the laboratory unit showed that it does not exceed 1.3 kW.*
KEYWORDS*: POTATO HEAP, IMPURITIES, LABORATORY INSTALLATION, EXPERIMENTAL STUDIES.*

1. Introduction

Harvesting root crops is one of the important operations in the technological process of its cultivation, which should be to ensure high-quality cleaning of potato heaps from soil and plant impurities, as well as cleaning the roots themselves from sticky soil, reducing their losses and damage. At the same time, it is necessary that a considerable mass of soil and other components of the pile (remains of haulm, the roots, other plant residues) are immediately separated from the rootstock during the digging of the potato layer or immediately after it is lifted. Then a significant mass of the under-ripe heap will not fall together with tubers inside the rootharvester. Many construction works and scientific research, both in Ukraine and abroad, were devoted to the problem of creation and research of reliable and efficient potato pile separators, which was reflected in the works [1-8]. However, according to the analysis of numerous studies, it was found that the existing potato harvesters with different principles of action of cleaning tools do not fully meet the above requirements. This is primarily due to sticking of cleaning tools by soil and plant residues, because often during the harvesting of potatoes the soil has a high moisture content and plasticity. It can also cause considerable damage to the tubers and consequently increase yield losses.

Considering the above, a spiral separator was developed, which has the ability to actively self-clean from clumped soil, as well as effectively capture and remove lumps of different sizes and shapes, including plant residues. Specified potato root-cleaner from impurities consists of five cleaning rollers, which are made in the form of cantilever spiral springs, associated with the drive in a rotary motion, with the mutual overlap and separating gaps are formed between the spirals, as well as feeding and discharging conveyor. preventing losses of potato tubers [9]. Also, the use of five wave-shaped cantilever cleaning spirals allowed to expand the separation working area, improve the quality of cleaning potato tubers from soil impurities and plant residues and as a consequence, increase the productivity of the potato pile cleaner.

To carry out experimental studies of the new construction of root-cartato cleaner from impurities we have developed a laboratory setup, which allows you to test and justify the basic construction and kinematic parameters of this cleaner.

The aim of the work is to conduct experimental studies of potato root cleaners from impurities on the basis of the development of a new construction of the laboratory unit for the implementation of these studies.

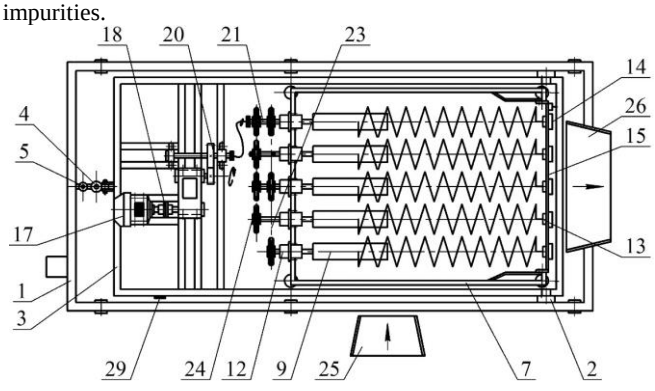
2. Results and discussions

To improve the quality and productivity of root harvesters, in particular to increase the efficiency of separation of excavated from the soil potato heap, we have developed a new construction of potato root cleaner from impurities, which received a patent of Ukraine for the invention [9].

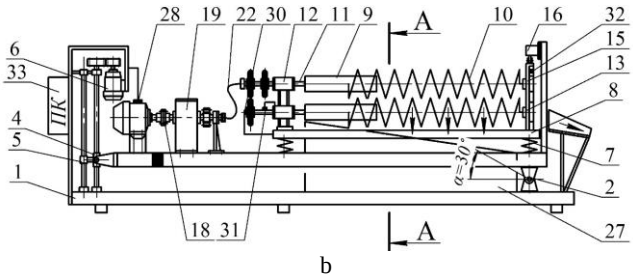
The spiral cleaner of root crops from impurities consists of the main frame, the feeding conveyor, several (in this case five) drive cleaning rollers, made in the form of cantilever spiral springs, installed in such a way that between the spirals themselves are formed mutual overlapping and separating gaps. The cantilever spiral springs are fixed with one end on the hubs connected to the drive shafts rotating in one direction.

The cleaning rollers, made in the form of spiral springs, are arranged in the longitudinal-vertical plane in a wave-like form at different heights, so that two longitudinally arranged cleaning channels are formed. The helical windings of all spiral springs are directed in the same orientation to their cantilevered ends. The cleaning rollers are located inside a movable frame having a rectangular shape, which is mounted on top of the main frame and which has an inclination at an angle α to the horizon. An unloading conveyor is connected to the other end of the movable frame. Flat rectangular protective screens are fixed around the cleaning rollers in the form of coil springs to prevent the loss of potato tubers.

Fig. 1 shows the structural diagram and general view of the laboratory installation, developed and manufactured specifically to conduct experimental studies of potato root cleaners from impurities.



a



b

c

Figure 1. *Constructional diagram of the laboratory unit for the study of potato root cleaners from impurities (a), side view of the laboratory unit (b) and its general view (c)*

The laboratory installation consists of the main frame 1, on which is movably mounted, with the help of the joint 2, the middle frame 3. The joint 2 is installed in the front of the frame 3, and the rear part of the frame movably connected with the lifting mechanism consisting of a screw pair 4, guide 5 and drive 6.

On the frame 3, movably, with the help of elastic supports 7, frame 8 is installed on which the working bodies – separators. Each separator consists of a drum 9 and a cylindrical spring 10 attached to it. The drum 9 is cantilevered to the shaft 11, which is installed in the bearing body 12. The second end of the separator with the help of the bracket 13 is supported on the slide bearing 14, the body of which is mounted on the moving wall 15. In the lower part of the wall is supported by elastic elements (not shown), and in the upper part it is connected to the vibrator 16.

The spring 10 has the ability to move along the axis of the drum 9, thereby changing the length of the working surface of the device. The cages forming the working surface of the cleaner are placed in two rows and in such a way that the coils of the springs of the lower 10 row are between the coils of the similar springs of the upper row. In this case, the wheelbase "*a*" remains constant, and the distance "*b*" can vary within the value of *Δ*, which is equal to the diameter *d* of the coil of the spring (Fig. 2).

The separator drive consists of an electric motor 17, a clutch 18, a variator 19, a cylindrical transmission 20, which are mounted on the frame 3. Torque from the cylindrical transmission to the drive shaft 21 of the separators is transmitted by a flexible shaft 22. From the drive shaft to the separator shafts of the upper row, the torque is transmitted by means of a chain transmission 23, and the lower row – by a chain transmission 24.

The device has a loading 25 and unloading 26 trays. In the lower part of the device, under the working surface, there is a tray 27 for soil.

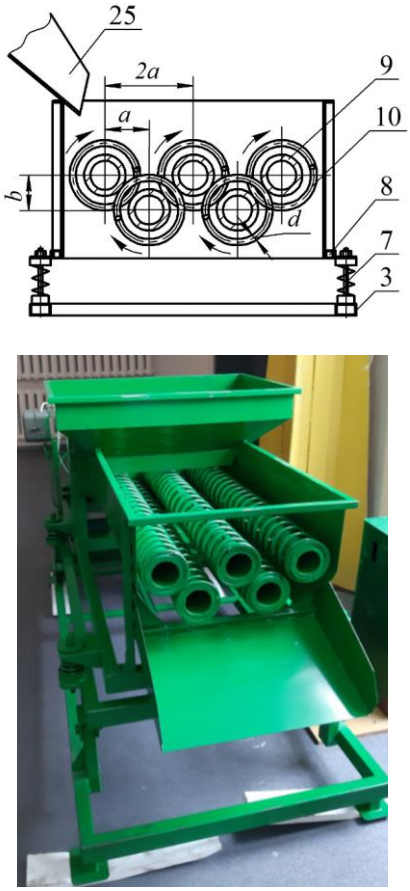


Figure 2. *Reciprocal arrangement of console spirals of laboratory installation*

In order to control the parameters of the separation process on the main components of the device installed a number of sensors: 28-32. The process is implemented using the control panel 33.

The laboratory installation for research of purifiers of root crops from impurity works as follows. A layer of soil with potato tubers is fed to the loading tray 25, which is cut by the working bodies of the potato harvester. The parameters of the formation are as follows: height – 22 cm; width – 41 cm; length – 100 cm; tuber content – 2…5%.

The layer falls into the area of action of the drums 9, which rotate in one direction, which ensures uniform distribution of the potato heap on the working surface of the laboratory installation. The working surface is formed by separators in the form of cylindrical springs 10 mounted on the drums 9.

The speed of rotation of the separators (155…310 rpm^{-1}), as well as their placement in two rows ensures the process of destruction of the formation and separation of potato tubers from the soil. Tubers entering the working area of the separators are sent to the storage area (tray 26) by means of coils of springs, and the soil in the form of gunpowder and small lumps accumulates in tray 27.

The construction of the unit involves the implementation of a number of factors that actively affect the separation process: oscillation of the separators in the vertical plane, changing the inclination of the working surface of the separators, changing the length of the working surface.

The construction of the laboratory unit includes a number of sensors to control the main parameters of the separation process: sensor 28 – power, 29 – angle of inclination of the working surface; 30 and 31 – speed of driving and driven shafts of separators respectively; sensor 32 – frequency and amplitude of oscillations of the working surface.

Also the calculations of the power required for the drive of the laboratory unit presented in this work were made. In this case, the resistance force of the movement of potato pile on the entire

working surface of the machine was taken into account, as well as the maximum allowable speed of the tuber on its active working surface and the overall efficiency factor.

The force of resistance to the movement of tubers on the working surface was determined by taking into account the weight of the heap and the total weight of the cleaning rollers, the coefficient of friction of the sliding of the tuber on the separating surface, the diameter of the pivot, on which the spiral spring is mounted, the coefficient of friction rolling, the diameter of the spiral spring.

The performed numerical calculations allowed to establish that the force of movement of the potato heap on the cleaning surface of the laboratory installation is 300…350 N.

If the maximum allowable speed of the tuber on the working surface will not exceed 2.0 $m \cdot s^{-1}$, the power to drive the installation will be in the range of 1.1…1.3 kW.

3. Conclusion

1. A new construction of the laboratory installation for experimental research of spiral type root cleaning machines, which has five cantilevered purification spirals, located in a wave-like manner at different heights, which makes it possible to expand the working area of potato cleaning and purification, has been developed.
2. The specified laboratory installation will allow to investigate experimentally influence of a number of factors on work of cleaners of spiral type, and also to substantiate their rational constructive and kinematic parameters at which qualitative performance of technological process of cleaning of working bodies and tubers of potatoes from sticky soil and vegetable impurity at the minimum losses and damages bulbs.
3. Calculations of the required power to drive the laboratory installation showed that it does not exceed 1.3 kW.

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