Pneumatic conveying plant for sorting fruits and root crops

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Abstract. The article deals with the classification of sorting fruits and root crops. When reviewing existing structures, their shortcomings were identified. The authors proposed a new design of the sorting device. The basic principle of operation of this design is based on the creation of a suction air flow inside a metal pipe. The device consists of a container with unsorted fruit, a corrugated plastic pipe of variable length with a tip, a clamp attached to a square metal pipeline. Inside this pipeline there are three rectangular holes of different sizes equipped with gates are fixed. In the lower part of the adapters, cyclones with corrugated plastic pipes of variable length with tips are fixed, descending into the corresponding containers. A protective mesh is installed in the rear part of the metal pipeline and a fan housing is attached, inside which the fan itself is located, driven by an electric motor and creating a suction air flow. The proposed device makes it possible to simplify the design, reduce the consumption of materials, reduce energy consumption, reduce the labor intensity of maintenance, increase productivity, and reduce the degree of damage to the surfaces of sorted fruits and root crops.

1 Introduction

Sorting is the process of separating products according to size and quality characteristics [1]. Of particular relevance is the sorting of fruits and root crops [2, 3, 4].

Most importantly, the sorting of fruits and root crops is necessary for the selection of substandard and spoiled products. This process also allows:

1. improve the commercial qualities of apples and fruits. Since the ugly and spoiled products will be removed, and the quality product will attract the attention of buyers;
2. get additional profit, since when sorting, you can select extra-class products, which are more expensive on the market than substandard products.

Carrying out sorting of fruits and root crops allows you to expand the sales market. Since a quality product is more readily purchased by both end users and chain stores.

Sorting can be done in two ways [5]:

1. by hand. When all actions are carried out with the help of workers. For this operation, special equipment is used. For example, inspection roller tables. Also, the
The sorting process can be carried out on belt conveyors, along which the product moves around the workshop.

2. automatically. For this procedure, special machines are used.

Also, sorting can be conditionally subdivided into 2 types [6]:

1. selection of substandard, spoiled fruits;
2. by caliber, breaking fruits into fractions similar in size.

This article discusses the issue of sorting fruits and root crops by caliber.

The authors noted the shortcomings of known technical solutions and looked for ways to eliminate these shortcomings [7-13].

When reviewing analogues, it was noted that most of the previously developed designs of sorting devices have major drawbacks. These include:

1. manufacturing complexity;
2. high material consumption;
3. high energy intensity;
4. high labor intensity of maintenance;
5. poor performance;
6. high degree of damage to the surfaces of sorted fruits and root crops.

Further, the authors of this article proposed a new technical solution in the field of sorting fruits and root crops, which makes it possible to simplify the design of the sorting device, increase its productivity and reduce damage to the surface of fruits and root crops due to their collision.

The main design idea proposed by the authors in the process of creating a new design of the sorting device for fruits and root crops was that the device for sorting fruits consists of a container with unsorted fruits supported on supports, a corrugated plastic pipe of variable length with a tip, which is attached with a clamp to a metal pipeline of a square section, inside of which there are three rectangular holes of different sizes, under which, with the help of bolted connections, square section adapters equipped with gates are attached, to a metal pipeline, cyclones are attached to the lower part of the adapters, in the lower part of which, with the help of bolted connections, adapters are attached, equipped with gates, and in the lower part with fixed corrugated plastic pipes of variable length with tips that sink to the bottom of the containers and rise as they are filled by reducing the length of the corrugated pipe of variable length, the containers rest on metal gaskets rigidly connected to rotating supports, moreover, a protective mesh is installed in the rear part of the metal pipeline and the fan housing is attached, which, like the metal pipeline, is supported respectively on the supports, the fan itself is located inside the fan housing, driven by an electric motor placed on the support, rigidly attached to the support through a scarf and transmitting torque to the fan through the cardan transmission.

The aim of the research is to develop a sorting device in order to increase the efficiency of operations for sorting fruits and root crops.

2 Results

At the Volga State University of Technology, at the Department of Machinery and Equipment Operation, a design of a device for sorting fruits and root crops was proposed [14]. Moreover, this sorting device is simple in design. In addition, it allows you to increase productivity, reduce material consumption, energy consumption, labor intensity of maintenance of the structure and reduce damage to the surface of fruits and root crops.

The device for sorting fruits and root crops (Figure 1) consists of a container with unsorted fruits 1, which rests on supports 2.

Corrugated plastic pipe of variable length 3 with a tip 4, which, using a clamp 5, is attached to a metal pipeline of square section 6. Inside the metal pipeline 6 there are three
rectangular holes of different sizes 7 under which, using bolted connections 8, square-section adapters 9 are attached, equipped with gate valves 10. Cyclones 11 are attached to the metal pipeline 5, in the lower part of the adapters 9.

**Fig. 1.** General view of the sorting device for fruits and root crops.

In the lower part of the cyclones, with the help of bolted connections 12, adapters 13 are attached, equipped with gates 14, and in the lower part with fixed corrugated plastic pipes of variable length 15 with tips 16. These pipes fall to the bottom of containers 17 and rise as they are filled due to reduction length. Containers 17 rest on metal spacers 18, rigidly connected to rotating supports 19. A protective mesh 20 is installed in the rear part of the metal pipeline 6 and the fan housing 21 is fixed, which, like the metal pipeline 6, rests respectively on supports 22 and 23. Inside the fan housing 21 the fan 24 itself is located, driven by the electric motor 25, placed on the support 26, rigidly connected to the support 22 through the scarf 27. The electric motor 25 transmits torque to the fan 24 through the cardan transmission 28.

The device works as follows.

The operator turns on the electric motor 25, which rotates the fan 24 through the cardan transmission 28. An intake air flow is created (shown by arrows). The operator brings a corrugated plastic pipe of variable length 3 with a tip 4 to the container of unsorted fruits 1. The suction air flow created by the fan 24 and the electric motor 25 sucks the fruits into the metal pipeline 6, in which the fruits are sorted by size, falling into rectangular holes 7-1 - for fine fractions, 7-2 - medium fractions, 7-3 large fractions into cyclones 11, through open gates 10. When at least one cyclone 11 is filled with fruit, which the operator sets through viewing windows 29, he turns on the reverse of the electric motor 25, creating a reverse air
flow to release the pipeline from fruits or root crops from accidental entry of some of them into inappropriate sorting holes and closes the gate 10. Turns off the electric motor 25. Then lowers the corrugated pipe of variable length 15 with a tip 16 to the bottom of the container 17. Then opens the gate 15 and the fruit spills out into the container 17. At the same time, as the container is filled, it gradually raises the tip 16 by reducing the length of the corrugated plastic pipe of variable length 15. After unloading the fruit of one of the cyclones 11, the gate 14 closes. The operator lifts the tip 16 above the container 17. The gate 10 opens and the cyclone filling cycle continues. Then the operator rotates the support 19, where the fruit has been dropped, to evenly arrange the fruit due to centrifugal force. To prevent fruit from entering the fan 24, a protective mesh 20 is installed on their way in the back of the metal pipeline 6. After the containers 17 are filled, they are removed using a loader and new ones are put in their place. The same is done with container 1. After it is empty, the empty container 1 is removed with the help of a loader, and a new one is put in its place.

3 Discussion

According to many researchers in the field of creating sorting devices for fruits and root crops with low damage to their surfaces is an urgent task [9].

Despite the fact that many well-known researchers have worked on this topic, the patent and literature search made it possible to conclude that similar developments in the field of agriculture are effective, namely for sorting fruits and root crops. The closest examples of such constructive solutions can be considered the designs proposed in the patents of the Russian Federation [10-12].

The disadvantages of such structures during a patent search were revealed:
1. manufacturing complexity;
2. high material consumption;
3. high energy intensity;
4. high labor intensity of maintenance;
5. poor performance;
6. high degree of damage to the surfaces of sorted fruits and root crops.

4 Conclusion

The proposed design of the sorting device for fruits and root crops allows:
1. simplify the design;
2. reduce material consumption;
3. reduce energy consumption;
4. reduce the labor intensity of maintenance;
5. increase productivity;
6. reduce the degree of damage to the surfaces of sorted fruits and root crops.

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