DESIGN ANALYSIS OF DISPENSERS AND DESIGN DEVELOPMENT OF A UNIVERSAL SEED DISPENSER

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Annotation. The article provides an analysis of the most common bulk material dispenser bunkers, including designs of screw dispenser bunkers. Some disadvantages of the screw dispensers used in the mordant workshops for the preparation of pubescent seeds have been identified. The design of a universal seed dispenser hopper has been developed, which allows simplifying the design, reducing energy consumption and mechanical damage to seeds.

Keywords: hopper dispenser, bulk, accuracy, density, productivity, arching, gate valve.

Introduction. Increasing crop yields and the safety of manufactured products has been and remains one of the priorities of the agro-industrial sector of the country. Among the measures to implement these tasks, a significant role is assigned to plant protection methods, one of which is seed etching in specialized workshops for the preparation of pubescent and bare seeds. Screw dispensers are widely used as volumetric dispensers in these workshops. These dispensers are reliable, simple in design, and versatile. They work well both when dosing omitted and exposed cotton seeds. However, they have some disadvantages that have not yet been eliminated.

Analysis of the literature on this issue. The maximum throughput of the dosing hopper should be greater than the maximum productivity of the pickler. Seed consumption during free flow depends mainly on the area of the dispenser opening and on the rate of material flow.

To date, many designs of dosing devices have been developed. This is due to the fact that the flow material has a wide range of physical, mechanical and technological characteristics; in addition, specific requirements are often imposed on the equipment, depending on the characteristics of the process. Basically, there are three types of dosing:

-volumetric;

- weight;

- massive.

Volumetric dispensers. Devices of this type are designed to work with liquid (sometimes gaseous) substances. This type of dispensers is easy to operate, durable and reliable, but has insufficient measurement accuracy when working with some types of products [1].

Weight dispensers. The optimal solution for dosing bulk materials with fractions of any size, as well as liquids. The popularity of these devices is explained by their versatility, optimal accuracy and high performance. Strain gauge weight measuring devices equipped with dispensers of this type are extremely convenient to operate – the weighing and dosing processes are fully automated, the control of the scales is reduced to manipulating the loading device. The only disadvantage of weight dispensers is the relatively low speed of their operation.

Mass dispensers. These dispensers can be used equally successfully to work with solid, bulk and viscous substances. They are used in a wide variety of industries. Mass dispensers combine reliability, measurement accuracy and relatively high operating speed [2].

Screw dispensers. In general, such dispensers are a screw enclosed in a casing and are used to supply materials such as powders, granular materials that are not subjected to grinding (Fig.1). The working body of this type can be positioned vertically, horizontally or obliquely. In practice, dispensers with multiple augers are also found. In order to maintain the uniformity of the flow, augers with variable pitch are used, which decreases towards unloading. In cases

where there is a possibility of crimping the material in the inner space of the dispenser, augers are used with an increase in the step in the direction of movement.

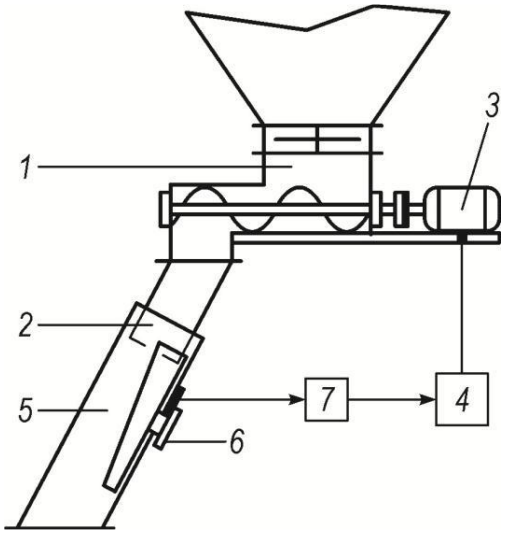

Figure 1. Schematic diagram of a screw weighing dispenser

The principle of operation of the screw weighing dispenser (Fig. 1). The screw feeder 1 takes the bulk material from the hopper and directs it to the flowmeter 2. The rotation speed of the screws can be smoothly changed using a controlled drive, which consists of an asynchronous gear motor 3 and a frequency converter 4. The flow of material enters the flowmeter and slides down the tray 5, attached to the load cell 6. An electrical signal from the load cell, proportional to the weight of the material on the tray, enters the micro controller 7, which calculates the flow rate. The measured capacity of the dispenser is continuously compared with the prescribed one, and when differences are detected, a constant correction of the screw rotation speed is performed through the frequency converter. Usually, the dosing error does not exceed 0.5% of the mass of the material passed through the dispenser [3].

Theoretical research. The classification of dosing equipment by design features is greatly influenced by the physical and mechanical properties of the material. First of all, these are: particle size, bulk density, fluidity, adhesion. The average particle size of bulk materials is classified as follows:

- lumpy (d > 10 mm);
- coarse-grained (d = 2...10 mm);
- fine-grained (d = 0,5...2,0 mm);
- powdery (d = 0,05...0,50 mm);
- dust-like (d < 0,05 mm).

The next criterion influencing the classification of dispensers according to the design principle is bulk density. This parameter depends on the size of the material flow of the particles, their average density, humidity, and the density of the particles in the layer. The density does not remain constant even when the bulk material is at rest. Under the influence of vibrations of the vessel walls, the bulk material condenses over time, and its bulk density reaches a certain limit value. In the process of movement, displacement, displacement, on the contrary, loosening of the material occurs. At the same time, the bulk density decreases, approaching the limit value. Bulk materials are distinguished by their bulk density: light (up to 600 kg/m^3), medium (600...1100 kg/m^3), heavy (1100...2000 kg/m^3), very heavy (more than 2000 kg/m^3) [2].

The productivity of the screw dispenser is determined by the formula [4]:

$$Q = \frac{60\pi D^2}{4} \times S \times n \times c \times \gamma \times \psi \qquad (1)$$

where: D – the outer diameter of the screw screw, m; S – screw pitch of the screw, m; n – angular speed of rotation of the shaft, min^{-1}; c – a coefficient that takes into account the effect of the angle of inclination of the screw axis to the horizon on its performance; γ – bulk weight of the material, kg/m^3; ψ – the filling coefficient of the screw body.

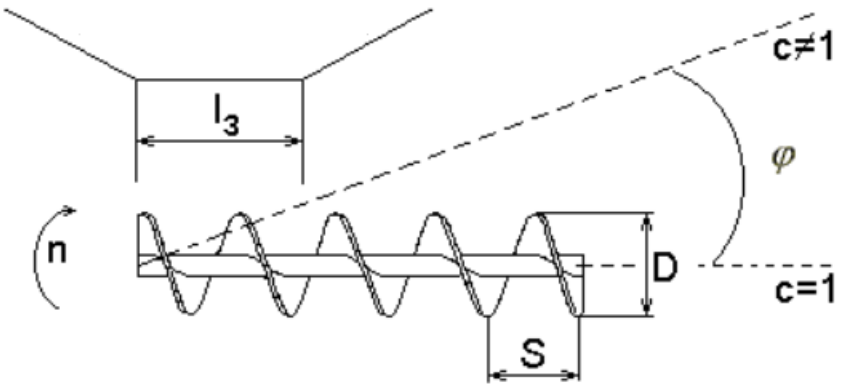

Figure 2. Screw parameters

The productivity of the screw dispenser is proportional to: the diameter of the screw D, the pitch of the screw S, the angular rotation speed of the screw n, and also depends on the parameters of the transported material, the filling factor of the screw ψ and the bulk weight γ. The performance of the screw dispenser is also affected by the spatial position of the screw, i.e. a coefficient that takes into account the influence of the angle of inclination of the screw axis to the horizon c (Fig. 2). All screw dispensers are divided according to the method of controlling the discharge rate into three large groups: with control of the screw rotation speed, with control in the unloading zone and with control in the loading zone. Screw dispensers with speed control most often have an auger with constant design parameters, regulation of the rate of issue by changing the speed of rotation of the auger requires a complex and expensive control system for the drive of discharge augers, when working at low rates of issue, significant fluctuations in the uneven distribution of material are observed.

Results. Seed dispensers have been introduced in the pickling workshops of the Republic for pickling pubescent cotton seeds [5], in which a scheme developed on the basis of patents [6, 7] is used as a dosing mechanism [6, 7] (Fig.3).

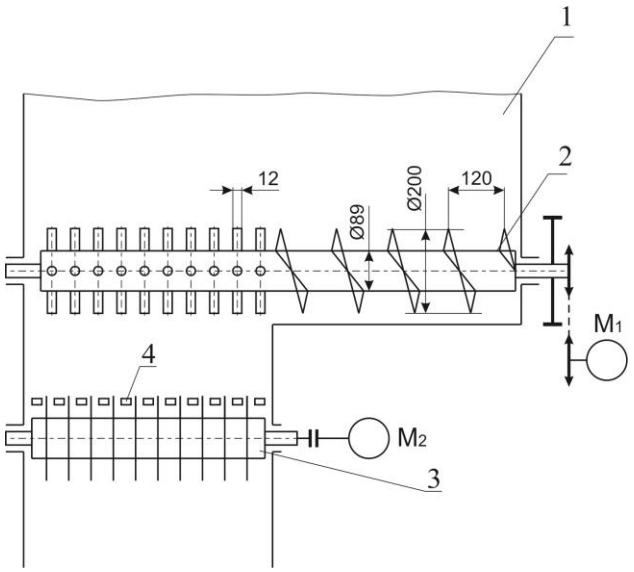

Figure 3. Diagram of the dosing mechanism of the dosing hopper

1-hopper; 2- combined shafts; 3-saw cylinder; 4-grate.

The disadvantage of this dispenser is the arching on top of the saw drum 4 due to the discrepancy between the seed supply by the spike drums 2 and the throughput of the saw cylinder. In addition, the presence of spike rollers and a combined dispenser with a saw cylinder increases the energy consumption of the device.

The purpose of the study. The purpose of our research is to simplify the design of a universal seed dispenser, reduce its energy consumption, mechanical damage to seeds and increase the accuracy of dosing of pubescent seeds. The task is achieved by the fact that a combined dispenser with a saw cylinder is not used on the device under development, augers are used, in which there are no screws on the last part that contribute to the fall of seeds down from the hopper.

In this case, the screw surfaces of the augers are made within the narrowing part of the hopper, a flap is located above the augers to regulate the supply of pubescent seeds, and the outlet pipe is connected to a rectangular shaft with a slide valve installed in it with a mechanism for regulating the productivity of feeding bare seeds.

Due to the above distinctive features in the proposed design of the universal seed dispenser, it becomes possible to simplify the design, reduce energy consumption, since there is no saw working body in it. In addition, due to its absence, the mechanical damage of the seeds is also reduced. All this will lead to a more efficient operation of the proposed universal dispenser for cotton seeds.

The essence of the developed design of the universal seed dispenser is explained by the drawings, where Fig.4 shows the longitudinal section of the device, Fig. 5 shows the front view (view of the augers).

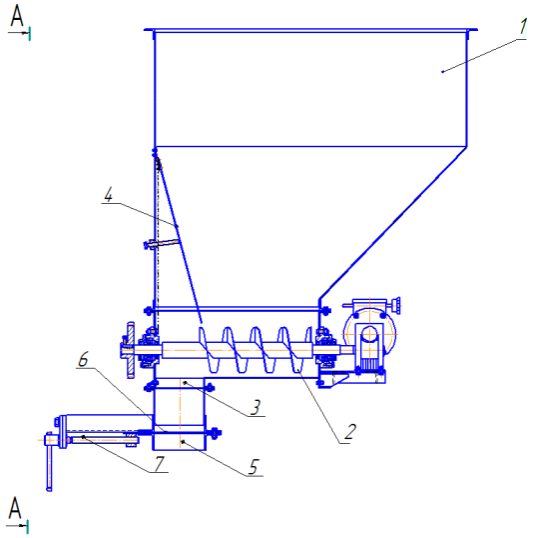

Figure 4. Scheme of a universal dispenser for cotton seeds

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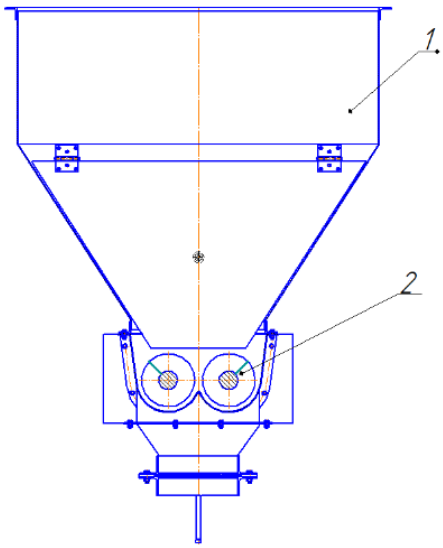

Figure 5. Diagram of a universal dispenser for cotton seeds, front view

The proposed universal seed dispenser contains the following main components: a hopper 1 with a certain volume for accumulating seeds with a tapering lower part, in which two augers 2 are installed, an outlet pipe 3, a flap 4 for adjusting the feed capacity of pubescent seeds and a rectangular shaft 5 with a slide flap 6 and a mechanism 7 for regulating the feed capacity of bare seeds according to a set scale. The universal seed dispenser works as follows.

The pubescent or bare cotton seeds are fed into the hopper 1, due to the tapering bottom of the hopper, the pubescent seeds fall onto the augers 2. The augers with screws drag the seeds towards the outlet pipe 3. There are no screws

on the last part of the augers 2, therefore, the pubescent seeds under gravity through the outlet pipe 3 connected by a rectangular shaft 5 exits the hopper and it is sent for further processing. In this case, the flap 4 above the augers is inserted into the closing position, and the slide flap 6 on the rectangular shaft 5 into the fully open position. To supply the bare seeds, open the flap 4, the bare seeds flow by gravity to the mine 5. The productivity of the bare seeds is regulated by a slide gate 6 with a mechanism 7 and the seeds exit the device and are sent for further processing. Currently, an experimental sample of the proposed dosing hopper has been manufactured, which is included in the universal seed pickler. His research was carried out to determine the main parameters of the seed auger and operating modes.

Conclusions. The analysis of the existing designs of hopper dispensers has revealed some of their shortcomings. An improved design of the screw hopper dispenser has been developed, which allows simplifying the design, reducing energy consumption and mechanical damage to seeds. The direction of further research is the choice of the volume of the hopper for continuous seed supply to the universal pickler.

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