International Journal of Advance Scientific Research
(ISSN – 2750-1396)
VOLUME 05 ISSUE 03 Pages: 79-88
OCLC – 1368736135

Journal Website: http://sciencebring.com/index.php/ijasr

Research Article

ANALYSIS OF DISPENSER DESIGN AND IMPROVEMENT OF THE DISPENSER DESIGN FOR FUZZY COTTON SEEDS

Submission Date: January 29, 2025, **Accepted Date:** February 28, 2025,
Published Date: March 31, 2025
Crossref doi: https://doi.org/10.37547/ijasr-05-03-12

N.T. Gofurov
Namangan Institute of Textile Industry, Uzbekistan

A.A. Akramov
Scientific Center of the Cotton Industry, Tashkent, Uzbekistan

Q. Jumaniyozov
Scientific Center of the Cotton Industry, Tashkent, Uzbekistan

J.Yuldashev
Namangan Institute of Textile Industry, Uzbekistan

ABSTRACT

The article presents the designs of hopper dispensers for bulk materials, including screw-type hopper dispensers, which are widely used. Some shortcomings of the screw dispensers used in seed preparation and treatment workshops have been identified. A new design of the hopper dispenser has been developed, which enables the improvement of its structure, reduction of energy consumption, and minimizes mechanical damage to the seeds.

KEYWORDS

Hopper dispenser, bulk material, accuracy, density, productivity, efficiency, accumulation, arch formation, slide valve.

INTRODUCTION

Increasing the yield of agricultural crops and preserving the harvested products has been and remains one of the primary tasks of the country's agro-industrial sector. Among the measures to achieve these goals, plant protection methods play a significant role, one of which is seed treatment in specialized workshops for preparing fuzzy and naked seeds.

Screw-type dispensers are widely used as volumetric dispensers in these workshops. These dispensers are reliable, simple in design, and versatile. They function well when dispensing both fuzzy and naked cotton seeds. However, they have certain drawbacks that have not yet been resolved.

Literature review on subject

The maximum throughput capacity of the hopper dispenser should be greater than the maximum processing capacity of the seed treatment machine. The seed flow rate during free discharge mainly depends on the dispenser opening area and the material discharge speed.

To date, numerous designs of dosing devices have been developed. This is due to the fact that material flow exhibits a wide range of physical, mechanical, and technological characteristics. Additionally, specific requirements are often imposed on the equipment depending on the process characteristics.

There are three main types of dosing:

- Volumetric dosing
- Gravimetric dosing
- Mass dosing

Volumetric dispensers

Devices of this type are designed to work with liquid (and sometimes gaseous) substances. This type of dispenser is convenient to use, durable, and reliable. However, it lacks sufficient measurement accuracy when working with certain types of products [1].

Gravimetric dispensers

These are the optimal solution for dosing bulk materials of any particle size, as well as liquids. Their popularity is due to their versatility, optimal accuracy, and high productivity. Load cell-based weighing devices equipped with this type of dispenser are highly convenient in operation—both the weighing and dosing processes are fully automated, and control is reduced to managing the loading device. The only drawback of gravimetric dispensers is their relatively low operating speed [1].

Mass dispensers. These dispensers can be effectively used for handling solid, bulk, and viscous materials. They are widely applied across various industries. Mass dispensers combine reliability, measurement accuracy, and relatively high operational speed [1].

Screw dispensers. In general, such dispensers consist of a screw enclosed in a casing and are used for feeding materials such as powders and granular substances that are not subject to grinding (see Fig. 1).

The working unit of this type can be positioned vertically, horizontally, or at an angle. In practice, dispensers with multiple screws are also found. To maintain uniform flow, screws with a variable pitch are used, decreasing toward the discharge end. In cases where there is a risk of material compression inside the dispenser, screws with an increasing pitch in the direction of movement are applied.

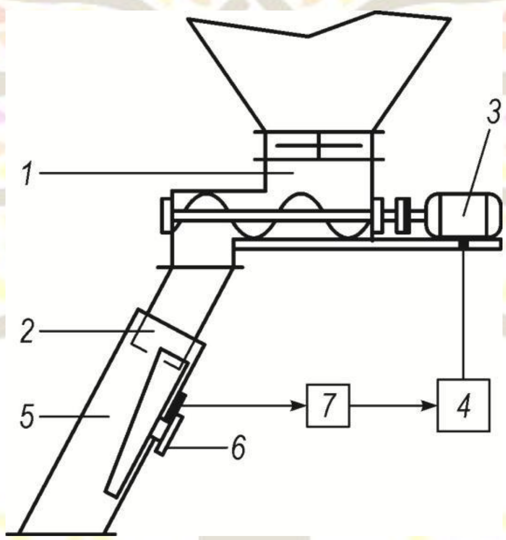


Figure 1. Schematic Diagram of a Screw Weighing Dispenser

Operating Principle of the Screw Weighing Dispenser (Fig. 1). The screw feeder (1) collects bulk material from the hopper and directs it to the flow meter (2). The rotation speed of the screws can be smoothly adjusted using a controlled drive, which consists of an asynchronous motor-reducer (3) and a frequency converter (4).The material flow enters the flow meter and slides down the chute (5), which is attached to the load cell (6). An electrical signal from the load cell, proportional to the weight of the material on the chute, is transmitted to the microcontroller (7), which calculates the flow rate.

Measured Performance and Theoretical Research,The measured performance of the dispenser is continuously compared with the preset value according to the recipe. If discrepancies are detected, the frequency converter adjusts the screw rotation speed in real time. Typically, the dosing error does not exceed 0.5% of the total material mass passed through the dispenser [3].

Theoretical Research. The classification of dosing equipment based on structural features is significantly influenced by the physical and mechanical properties of the material. The key factors include:

- Particle size
- Bulk density
- Flowability
- Adhesion

Bulk materials are classified by average particle size as follows:

- Chunky (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)

Bulk Density and Its Influence on Dispenser Classification.Another key factor influencing the classification of dispensers by structural principle is bulk density. This parameter depends on:

- Particle size within the material flow
- Average particle density
- Moisture content
- Particle packing density within a layer

Bulk density is not a constant value, even when the material is at rest. Due to vibrations affecting the container walls, bulk material compacts over time until it reaches a certain limit density. Conversely, during movement, transportation, or mixing, the material loosens, reducing its bulk density to another limit value.

According to bulk density, loose materials are classified as follows [2]:

- Light (up to 600 kg/m^3)
- Medium (600–1100 kg/m^3)

- Heavy (1100–2000 kg/m^3)
- Very heavy (over 2000 kg/m^3)

The performance of a screw dispenser is determined by the following formula [4]:

$$Q=60\Pi D^2/4\times S\times n\times c\times\gamma\times\psi$$

where:

- D – outer diameter of the screw, m
- S – screw pitch, m
- n – angular speed of the shaft, rpm
- c – coefficient accounting for the effect of the screw axis inclination angle relative to the horizontal plane
- γ\gamma – bulk density of the material, kg/m^3
- ψ\psi – filling coefficient of the screw casing

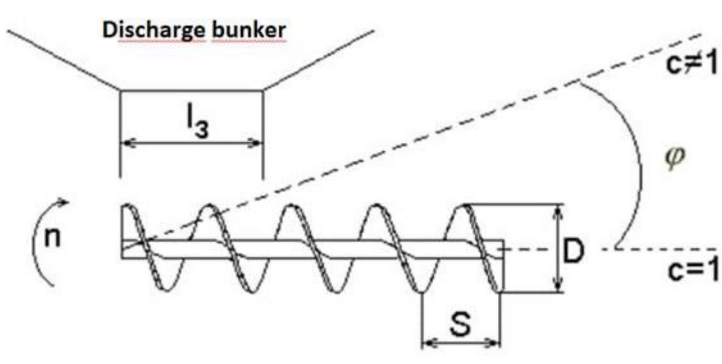


Figure 2. Screw Parameters

The performance of a screw dispenser is proportional to the screw diameter DD, screw pitch SS, and angular velocity nn. Additionally, it depends on the parameters of the transported material, the screw filling coefficient ψ\psi, and the bulk density γ\gamma. The spatial position of the screw also affects its performance, particularly the coefficient cc, which accounts for the inclination angle of the screw axis relative to the horizontal plane (see Figure 2).

All screw dispensers are categorized into three main groups based on their feed rate control method:

1. Frequency-controlled screw dispensers
2. Discharge zone-controlled screw dispensers
3. Loading zone-controlled screw dispensers

Frequency-controlled screw dispensers typically feature screws with fixed design parameters. Adjusting the feed rate by changing the screw rotation frequency requires a complex and expensive control system for the discharge screw drive. At low feed rates, significant fluctuations in material discharge uniformity are observed.

RESULTS

In the seed treatment workshops of the Republic, seed bunker-dispensers have been introduced for treating fuzzy cotton seeds [5]. These dispensers utilize a dosing mechanism based on a design developed from patents [6, 7] (see Figure 3).

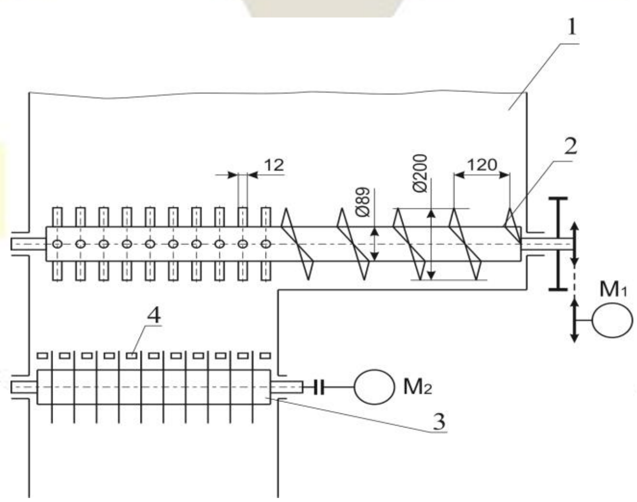


Figure 3. Schematic Diagram of the Bunker-Dispenser Dosing Mechanism
1 - Bunker; 2 - Combined Shafts; 3 - Saw Cylinder; 4 - Grate.

A significant drawback of this dispenser is the formation of vaults above the saw drum (4) due to the mismatch between the seed supply rate of the peg drums (2) and the throughput capacity of the saw cylinder. Additionally, the presence of peg rollers and a combined dispenser with a saw cylinder increases the energy consumption of the device.

Research objective.The objective of this study is to simplify the design of the fuzzy seed dispenser, reduce mechanical damage to seeds, and improve the accuracy of dosing fuzzy planting seeds.

This goal is achieved by modifying the seed bunker in the developed device. A gate mechanism is introduced to regulate seed supply into the combined augers located at the bottom of the bunker. The final section of the augers lacks screw blades, facilitating seed descent from the bunker. The screw surfaces of the augers are designed within the narrowing section of the bunker, where seed flow is controlled by a shutter mechanism. The outlet pipe is connected to a rectangular shaft equipped with a sliding gate that has a performance regulation mechanism for seed supply.

Due to these distinctive features, the proposed seed dispenser design is simplified by eliminating the sawing working element with grates used for regulating performance. The absence of this component also reduces mechanical seed damage, leading to more efficient operation of the fuzzy cotton seed dispenser.

The essence of the developed dispenser design is illustrated with technical drawings:

- Figure 4 shows the longitudinal section of the device.
- Figure 5 presents the front view (showing the augers).

International Journal of Advance Scientific Research
(ISSN – 2750-1396)
VOLUME 05 ISSUE 03 Pages: 79-88
OCLC – 1368736135

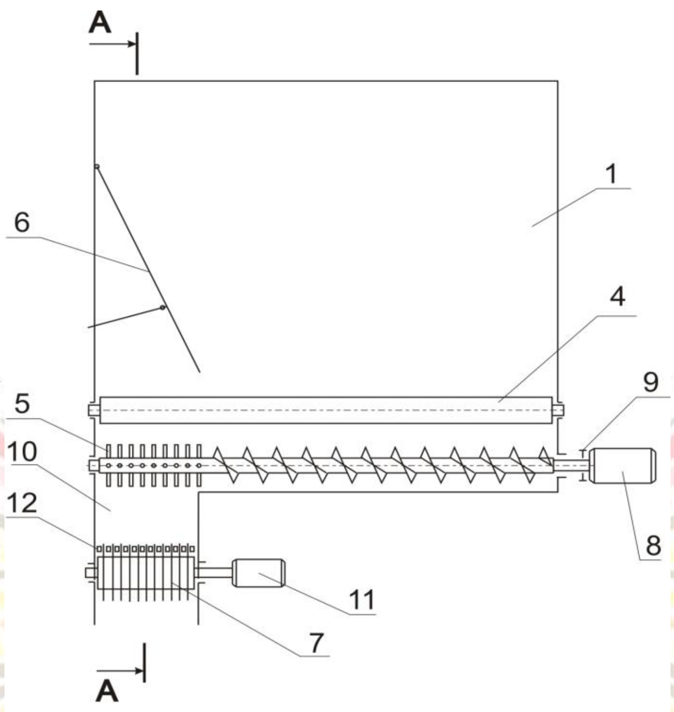
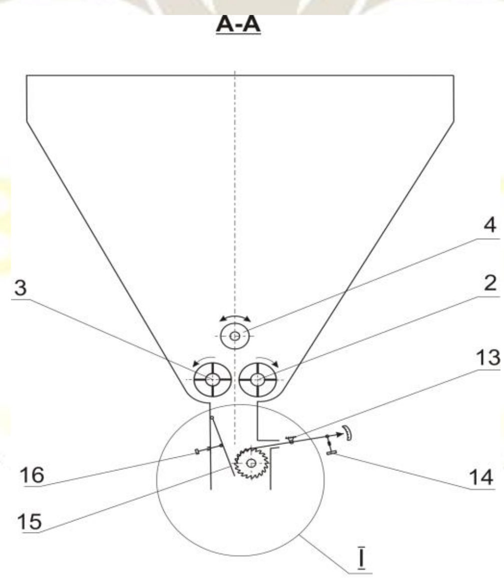


Figure 4. Diagram of the Improved Fuzzy Cotton Seed Dispenser



Фиг.2

Figure 5. Diagram of the Improved Fuzzy Cotton Seed Dispenser (Front View)

The proposed fuzzy seed dispenser consists of the following main components:

International Journal of Advance Scientific Research
(ISSN – 2750-1396)
VOLUME 05 ISSUE 03 Pages: 79-88
OCLC – 1368736135

Hopper (1) – A container of a specific volume for accumulating fuzzy seeds, with a tapered lower section.

Combined augers (2) – Two augers positioned inside the hopper.

Axis (3) – Supports the movement of the augers.

Buffer drum (4) – Helps in regulating seed flow.

Spikes (5) – Aid in seed separation and movement.

Shutters (6 and 15) – Adjustable elements for controlling seed flow.

Saw drum (7) – Facilitates the dosing process.

Drive mechanisms (8 and 11) – Power the system.

Coupling (9) – Connects drive components for smooth operation.

Shaft (10) – Ensures proper alignment of components.

Grates (12) – Filter and guide seed movement.

Combs (13) – Assist in separating seeds efficiently.

Screw mechanisms (14 and 16) – Allow regulation of seed feed rate based on a calibrated scale.

Improved Fuzzy Seed Dispenser: Operating Principle and Conclusions.

Operating Principle.The improved fuzzy seed dispenser functions as follows:

1. Seed Input: Fuzzy cotton seeds are fed into hopper (1). Due to the tapered lower section of the hopper, the seeds naturally fall onto combined augers (2).

2. Seed Transport: The augers, equipped with screw blades, transport the seeds towards the rectangular shaft (10).

3. Gravity Discharge: At the end of the augers, the screw blades are absent, allowing the seeds to fall freely under the force of gravity through rectangular shafts (10) for further processing.

4. Flow Control:

o The shutter (6) above the augers is positioned in a closed state to regulate seed flow.

o The sliding gate (16) on the rectangular shaft (10) is set to an open position, ensuring controlled seed discharge.

Experimental Implementation.A prototype of the proposed hopper-dispenser has been manufactured and integrated into the technological line for processing fuzzy planting seeds. Studies will be conducted to determine the key parameters of the improved dispenser.

Conclusions

Identified Issues in Existing Designs: The analysis of current hopper-dispenser designs has revealed certain shortcomings, particularly in complexity and mechanical seed damage.Developed Improvement: A new screw-based hopper-dispenser design has been proposed, simplifying the structure and reducing mechanical seed damage.Future Research Direction: Further theoretical and experimental studies will focus on defining the key parameters of the improved hopper-dispenser.

References

1. STADS. Dosing of bulk materials [Internet]. Available from: http://stads.ru/uslugi/kompleksnye-resheniya/dozirovanie
2. Shubin I.N., Sviridov M.M., Tarov V.P. Technological machines and equipment: bulk materials and their properties. Tambov: Tambov State Technical University Publishing House; 2006. 76 p.
3. Baltic Service-Nord. Description of a continuous weighing dispenser with a four-screw feeder [Internet]. Available from: http://bsnord.narod.ru/dosator.html
4. Grigoriev A.M. Screw conveyors. Moscow: Mashinostroenie; 1972. 84 p.
5. Rakipov V.G., et al. Development of a bunker-dispenser for delinted cotton seeds. Tashkent: Scientific and Technical Society, JSC "Paxtasanoat ilm"; 1999. 92 p.
6. Rashragovich A.Y., Korabelnikov R.V., Bordanovsky V.V., Rashragovich Y.A. Feeder of a fiber-processing machine. USSR Patent No. 1379359. Bulletin No. 9; 1988.
7. Dyachkov V.V., Maksudov E.T., Rakipov V.G., et al. Bunker-dispenser for delinted cotton seeds. Patent IAP No. 02654. Bulletin No. 2; 2005.