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JUSTIFICATION OF THE BUCKET VOLUME OF THE DOSING DRUM AND ITS EFFECT ON OPERATIONAL EFFICIENCY

1 Aloydinov M. G.
1 Gayratov J. G.
2 Djamolov R. K.
1Fergana State Technical University,
2Research Institute of Cotton Crops

Abstract

The article examines the determination of the volume of the blade-type buckets of a dosing drum and analyzes its influence on the cotton seed feeding process. Based on geometric parameters, the bucket volume is calculated, and design solutions ensuring uniform seed feeding under operating conditions are substantiated. The influence of blade height in the range of 17–26 mm was experimentally studied, and it was found that at a value of 23 mm the optimal productivity and feeding uniformity are achieved.

Keywords: Dosing drum, bucket volume, cotton seeds, geometric parameters, productivity, coefficient of variation, feeding uniformity.

Introduction

The main purpose of determining the volume of the proposed dosing feeder drum's paddle buckets is to substantiate the geometric parameters that ensure uniform and non-clumping transport of fluffy cotton seeds at the specified productivity level. Based on the determined parameters, the design of the paddle-bucket dosing drum is developed.

As the research object, a dosing drum with a diameter of $D = 250$ mm, a length of $L = 260$ mm, and $z = 6$ paddles was selected. The machine productivity was assumed to be $G = 600$ kg/h [1].

Based on the given parameters, determining the bucket volume requires calculating the mass of cotton seeds transported during one rotation of the drum. According to technical specifications, the rotation speed of the feeding drum varies between 12–16 rpm, and an average value of $n = 14$ rpm (0.23 rps) was adopted for calculations. Under these conditions, the mass of cotton seeds delivered per drum rotation was determined.

For evaluating the seed volume, an average bulk density of $\rho = 420$ kg/m³ was assumed [2]. According to the calculations, the mass of 0.726 kg of cotton seeds transported in one drum rotation corresponds to a volume of $V = 0.00172$ m³. Since the number of paddles is $z = 6$, the volume corresponding to each bucket is $V_1 = 0.000286$ m³.

In practice, due to the high adhesiveness of fluffy cotton seeds, the buckets are not completely filled. Therefore, a filling coefficient of $k = 0.5–0.6$ was adopted, and the constructive (design) bucket volume was determined accordingly. This value represents the effective working volume of the bucket.

The geometric parameters of the bucket were evaluated based on the cross-sectional area along the drum length. Since the bucket has the shape of a circular sector between the paddles, its cross-sectional area was determined using the sector area formula. As a result of calculations, the covering radius was found to be $r = 0.108$ m. Accordingly, the paddle height was $h = R - r = 0.017$ m, i.e., 17 mm.

The obtained results theoretically indicate that a sufficient bucket volume is formed. However, due to the high adhesion of fluffy cotton seeds, there is a possibility of material accumulation inside the bucket. Therefore, it is considered appropriate to increase the paddle height to a certain extent. In this case, the seeds will be freely accommodated in the bucket and discharged without accumulation during drum rotation.

Based on the calculations, the optimal working volume of each bucket was found to be approximately 0.0005 m³. To ensure this volume, it is recommended to set the paddle height within the range of 20–25 mm. These parameters allow uniform feeding of cotton seeds while considering their adhesive properties.

Since the outer diameter of the dosing drum is constant, when the paddle height is set within 20–25 mm, the drum cover diameter ranges from 200 to 210 mm.

The theoretical calculations were carried out for an ideal condition; however, in practice, several factors must be taken into account, such as the mutual adhesion of cotton seeds, their possible discharge from the bucket due to vibration effects, and incomplete filling of the buckets. Therefore, experimental investigations were conducted for different values of paddle height (17, 20, 23, and 26 mm) (Table 1).

Table 1 **Effect of Paddle Height on the Amount and Uniformity of Seed Delivery**

Paddle height, h (mm)	Seed mass collected in 5 seconds (g)					Mean value, $\bar{m}$ (g)	Standard deviation (σ), g.	Coefficient of variation V, %	Productivity (kg/h)
	1	2	3	4	5				
17	610	625	650	640	655	636	18,5	2,9	458
20	660	670	680	685	675	674	9,6	1,4	485
23	770	785	800	795	795	789	11,9	1,5	568
26	790	805	820	840	825	816	19,2	2,3	588

The experimental results (Table 1) show that variations in paddle height have a direct effect on both the amount of material conveyed and its uniformity. For example, at h = 17 mm, an average of 636 g of seeds was delivered, with a productivity of 458 kg/h, while the coefficient of variation was 2.9%. This indicates insufficient bucket capacity, resulting in non-uniform material feeding.

When the paddle height was increased to 20 mm, the average mass reached 674 g and productivity increased to 485 kg/h, while the coefficient of variation decreased to 1.4%. This demonstrates that the bucket volume becomes more optimized.

At h = 23 mm, the average mass was 789 g and productivity reached 568 kg/h, with a coefficient of variation of 1.5%. In this case, a high level of feeding uniformity was still maintained.

When the paddle height was further increased to 26 mm, productivity rose to 588 kg/h; however, the coefficient of variation increased to 2.3%. This can be explained by excessive bucket volume, which leads to seed accumulation and irregular discharge.

The analysis shows that increasing paddle height up to a certain limit improves productivity and stabilizes material feeding. However, excessive increase leads to seed accumulation inside the bucket, resulting in reduced feeding uniformity.

Therefore, the optimal paddle height is recommended to be h = 23 mm. At this value, both high productivity and stable material feeding are simultaneously ensured.

To provide a more precise evaluation of the obtained results, the combined effect of productivity (Q) and coefficient of variation (V) will be analyzed graphically (Fig. 1).

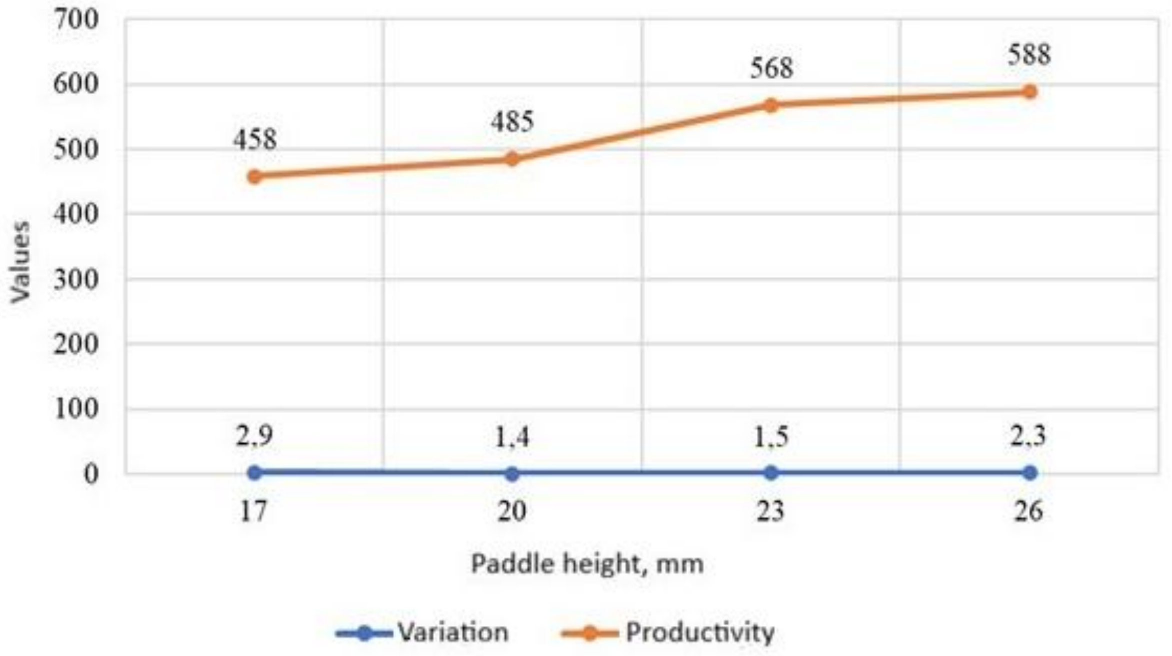

Figure 1. Effect of paddle height on productivity and feeding uniformity

The graphical analysis (Fig. 1) also confirms that productivity increases with an increase in paddle height; however, the coefficient of variation reaches its minimum value within the range of 20–23 mm. Further increase in paddle height leads to a deterioration in feeding uniformity.

Based on these results, it is appropriate to consider further improving productivity in subsequent studies by optimizing the drum rotational speed while maintaining feeding uniformity.

References

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