International Journal of Advanced Research in Science, Engineering and Technology

Vol. 12, Issue 9, September 2025

ISSN: 2350-0328

IMPACT FACTOR 7.150

Assessing the Completeness of Manure Collection by a Mobile Manure Collection Machine

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ABSTRACT: In this article, the completeness of manure collection by a mobile manure collection machine used in cattle farms is evaluated. The mobile manure collection machine was developed on the basis of a front-body tractor. A screw-type collecting working organ was installed on the tractor. The collection performance was assessed by changing the screw's rotation speed. During the research, the design and parametric characteristics of the machine's working organ and the physical-mechanical properties of the manure layer were taken into account. As a result, proposals were developed to improve the efficiency of manure collection.

KEY WORDS: Cattle farming, mobile manure collection machine, collection completeness, auger, rotational speed.

I.INTRODUCTION

In cattle farms, the timely and high-quality collection of manure is an important technological process that ensures production hygiene, livestock health, and overall production efficiency. Traditional manual collection methods are labor-intensive, time-consuming, and do not fully meet hygienic requirements. Therefore, in recent years, mobile manure collection machines have been widely introduced. Such machines, using auger or scraper mechanisms, quickly and completely collect manure and transfer it through a conveyor to a bunker or transport vehicle.

The completeness of manure collection depends on many factors: the design and parametric characteristics of the working organ, the thickness and moisture of the manure layer, the travel speed, and the auger rotation frequency [1, 3, 4]. If the collection completeness is low, residual layers of manure remain, leading to an increase in ammonia levels, deterioration of the microclimate, and a higher risk of pathogenic microorganisms spreading in the farm environment [2, 6, 11].

Therefore, evaluating the efficiency of the working organs of mobile manure collection machines, particularly determining the completeness of collection, is one of the urgent issues for both practice and scientific research [5, 7–10]. In this article, the completeness of collection of a screw-type mobile manure collection machine, developed on the basis of a front-body tractor, is studied experimentally, and the optimal operating modes are determined.

II. METHODOLOGY

As the object of the study, a mobile manure collection machine developed on the basis of a front-body tractor was selected. The machine consists of a screw-type collecting mechanism mounted on the front part and an inclined conveyor that transfers the manure to the bunker (Fig. 1). The auger has a diameter of 250 mm, a pitch length of 150 mm, and a working width of 2 m. The auger rotation frequency is increased from 300 rpm to 650 rpm through a reducer driven by the tractor's power take-off shaft.

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IJARSET IMPACT FACTOR 7.150

Fig. 1. General view of the mobile manure collection machine developed on the basis of a front-body tractor

The experiments were carried out at the "Amirkul Bobo" cattle-breeding complex in Muzrabat district, Surkhandarya region. The research was conducted under real operating conditions close to the natural circumstances of agricultural production. When determining the physical and mechanical properties of the manure layer at the research site, its moisture content varied between 65–80% depending on the season, and its density ranged from 750 to 950 kg/m³.

Experimental procedure

1. The experiment was conducted on plots with different manure layer thicknesses.
2. During the machine's operation, the mass of the collected manure and the actual mass of manure on the field were measured separately.
3. Using a tachometer installed on the machine, the tractor's power take-off shaft rotation speed (from 400 rpm to 650 rpm) was monitored.
4. The machine's working speed was maintained within the range of 1.5–2.5 km/h during the experiments.

The collection completeness of the machine was determined using formula (1).

$$\eta = \frac{Q_c}{(Q_c+Q_r)} * 100\ \% \quad (1)$$

where:

Q_c - mass of manure collected by the machine, kg;

Q_r - residual mass of manure in the field, kg.

The obtained results were processed in Microsoft Excel, and graphs showing the relationship between auger rotational speed and collection completeness were generated.

III. RESULTS AND ANALYSIS

The experimental tests were carried out on a screw-type mobile manure collection machine operating on the basis of a front-body tractor. The operating modes were evaluated by varying the engine speed from 900 rpm to 2200 rpm. The power take-off shaft and auger rotational speeds were changed proportionally, and the completeness of manure collection was determined experimentally and recorded in a table (Table 1).

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IJARSET IMPACT FACTOR 7.150

Table 1. Engine speed, power take-off, auger rotational speed, and collection completeness

Engine speed (rpm)	Power take-off and auger rotational speed (rpm)	Collection completeness (%)
1400	400	82
1580	450	89
1760	500	95
1940	550	96
2110	600	94
2200	625	94

Analyzing the obtained results, it can be stated that the proportional change in the power take-off and the auger rotational speed significantly affects the collection completeness. The collection completeness increases rapidly above 1500 rpm and reaches almost its maximum value (95–96%) in the range of 1700–1900 rpm. Further increasing the engine speed beyond 1900 rpm by pressing the accelerator pedal hardly improves collection completeness, but it does increase fuel consumption and mechanical wear.

The relationship between auger rotational speed and collection completeness is presented in Fig. 2, where the curve is observed to reach a saturation point at around 1700–1900 rpm. Beyond this point, increasing the rotational speed is considered energetically inefficient.

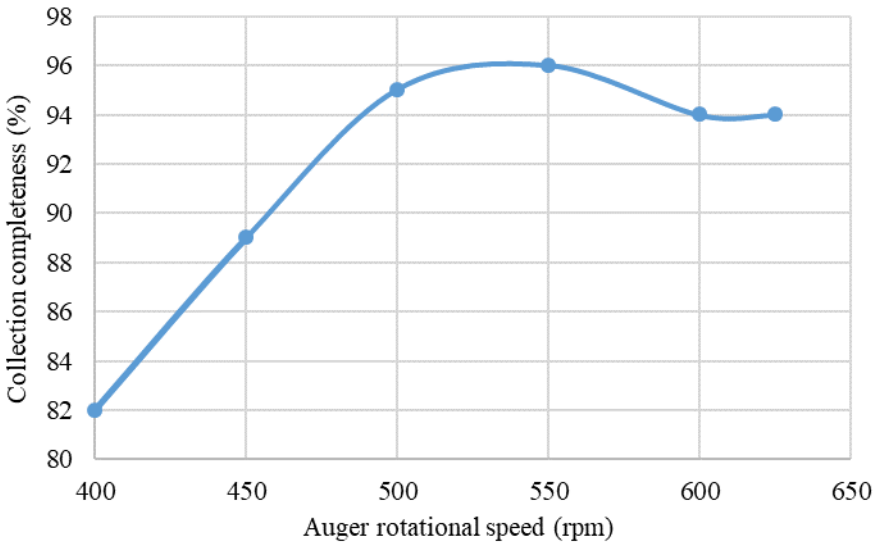

Fig. 2. Relationship between auger rotational speed and collection completeness.

The obtained results make it possible to select the optimal operating mode for mobile manure collection machines. This, in turn, reduces fuel consumption, slows down equipment wear, and increases collection completeness.

IV.CONCLUSION

During the study, the performance of the front-mounted tractor-based mobile manure collection machine was evaluated based on the relationship between the auger rotation speed and the collection efficiency. Based on the obtained results, the following conclusions were drawn:

1. **Relationship of rotation speeds:** When the engine speed was varied within the range of 1400–2200 rpm, the power take-off and auger speeds also increased proportionally. Increasing the engine speed significantly improved the auger's efficiency in conveying and collecting manure.
2. **Collection efficiency:** At auger speeds above 430 rpm, the collection efficiency exceeded 86% and reached a maximum of 95–96% within the range of 500–550 rpm. Increasing the auger speed above 550 rpm did not significantly improve collection efficiency, but it increased fuel consumption and mechanical wear.

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3. **Optimal operating mode:** For maximum efficiency and economical operation of the machine, it is recommended to maintain the engine speed within the range of 1700–1900 rpm. In this case, the auger speed is 500–550 rpm, and manure collection is carried out almost completely.

4. **Practical significance:** The use of the recommended operating mode ensures reduced fuel consumption, lower mechanical wear of the equipment, and improved collection efficiency in livestock farms.

- Reduces fuel consumption;
- Extends the service life of equipment components;
- Speeds up the cleaning process on farms and improves sanitary-hygienic conditions.

5. The research findings can be applied in developing technological settings of mobile manure collection machines and in designing new constructions.

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