PREREQUISITES FOR THE DESIGN OF AUTOMATIC DOSER MACHINE OF CONCENTRATED FEEDS OF SMALL RUMINANTS

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Abstract: The paper considers the need for designing a dispenser for automated delivery of concentrated feed of small ruminants. Provides an analysis of the criteria for choosing optimal of auger conveyor parameters to ensure the required dosing accuracy for the specific purpose.

KEYWORDS: E-LEARNING, MODEL, EFFICIENCY, EFFECTIVENESS, GPS, PROTECTION

INTRODUCTION: Individual and accurate dosing of concentrated feed is still an unresolved problem for modern and high-yielding goats and sheep. The lack of automated solutions in this area leads to increased costs for animal husbandry and incomplete use of genetic potential. To create such a device to be used on livestock farms where the environment is unfavorable, it is necessary to find an effective solution with a simple, reliable and inexpensive construction that guarantees the necessary feed distribution accuracy.

EXPLANATION: The amount of feed consumed by small ruminants is strongly associated with the intake of nutrients. The level of available nutrients determines how much milk can be produced. Available nutrients can come from what is consumed through the diet or taken from their reserves. If nutrient consumption is not enough to meet nutrient requirements for milk production, animals will have to mobilize their nutritional reserves in the body to provide the missing nutrients. The reserve nutrients that animals usually mobilize are energy (fats) and proteins (tissues). When this happens, the animal loses body weight, which is normal for high-performance HDI. The combination of nutrients provided by the diet and derived from body supplies must be sufficient to provide the necessary nutrients for the amount of milk that is produced. If these two sources can not obtain adequate nutrients, HDI will reduce milk production to match the available nutrients: nutrients (diet + body reserves) = production (milk + body weight). When HDI feeds on a high nutritional level but does not have the genetic capacity to produce the corresponding amount of milk, they will accumulate the excess energy they consume as body fat. In this way they accumulate weight.

Therefore, appropriate amounts of nutrients should be provided to maintain the level of milk production that are genetically capable of producing. Concentrated feed has a high cost and its ineffective application reduces the cost of production in the herd.

Existing GPP practice of concentrated feed does not take into account the individual needs of animals. Now nutrition is the same for all animals. This leads to malnutrition of animals with higher productivity and ineffective feeding of animals with lower productivity.

The technical and technological capabilities for animal identification (RFID) exist and, moreover, official veterinary identification is required throughout the EU. It is possible, however, to use these achievements in conjunction with appropriate hardware and software to manage an appropriate metered dose dispenser for concentrated feed.

There is no evidence of research and implementation of such a decision in scientific and company literature (Kelles, R., 2009).

In this connection, the author of the article develops a dissertation on the topic “Investigation of an automated feeding device for farms for small ruminants”. For this purpose, it is envisaged to use a precision screw dispenser (Figure 1) for individual nutrition of HDW using RFID and electronic mechanical control.

Systemic studies of auger conveyors, dispensers, mixers began in the early 1960s (Rehkugler, G., & Boyd, L., 1961). Research has evolved both theoretically and experimentally.

In the field of theoretical studies up to this period the calculations of the auger parameters refer purely to their geometric parameters.

As a result of the observations of the auger operation, there are discrepancies between the calculated values of the augers and the expected performance, energy consumption indicators. In practice, performance is lower than the nominal.

Fig. 1. Principal scheme of a screw conveyor for concentrated feed
In this regard, the researchers apply the theory of dimensions and the theory of similarity. Thus, they achieve a significant extension of the research criteria. This enables detailed experimental research on various new arguments and benchmarks on the workflow in terms of productivity, the power required. The volume efficiency criterion of the auger is entered.

Studies using the theory of similarity and dimensions were conducted in Bulgaria by Professor Ivan Georgiev with regard to auger mixers.

Researchers from the United States, Australia, Hungary, Germany, as well as institutions such as the Association of Agricultural Engineers and Biology ASABE (American Society of Agricultural and Biological Engineers).

As a result of these studies over 60 years it has been found that the processes of the auger conveyors are complex and contradictory.

When choosing parameters for a screw conveyor, the characteristics of the materials transported, the construction parameters, the kinematic parameters (Benkő, J., 1997) must be taken into account.

The controversy of the process is expressed in the discrepancy between theoretical and experimental performance. Experimental performance is less than theoretical. This also determines the demand for such a combination of constructive and kinematic parameters in accordance with the characteristics of the transported (dosed) material so as to achieve compactness and acceptable dosing accuracy.

In order to achieve the required accuracy, up to 5% combined with the compactness of the device, appropriate diameter, step, diameter ratio, minimum rotational speed, suitable auger material, which will be subjected to conveying of concentrated feed aggression of fat, carbohydrates, proteins and various microelements.

From the review, it has been found that in order to achieve high precision, it is necessary to combine such parameters as to allow for a high constant coefficient of filling of the auger. The high degree of filling of the auger must also be achieved at different humidity and level of the concentrated feed in the hopper. The researchers agree that the ratio of the step to the diameter of the auger should be within the range of 0.8 ... 1.1. In order to achieve high dosing accuracy, it is advisable that the step is small. Then for one turn the dose will be small. The ability to control the dose by stopping the rotation for less than one turn makes it possible to control small doses. For example, if the auger control can stop it at one turn the dose will be small. The ability to control the dose by stopping the rotation for less than one turn makes it possible to control small doses. For example, if the auger control can stop it at one turn the dose will be small.

Designer dosing calculations include determination of performance, propulsion power and estimation of the dosing error.

Screw dosers are used to feed and dispense grain, powder and related materials. Their application takes into account the characteristic crushing, which is inevitable as a result of grinding the particles of material between them and contact with the working organs. For this reason, in grain and seed transport, agriculture is preferable to rational and elevators, but in the present case, in the final stage of dosing, they are most suitable. The screw dispensers are characterized by stable flow and sustainable transport technology.

Continuous dosing provides a constant flow rate at a certain rate of material.

Table 1 gives adjustments to the performance of the auger from the slope to the horizon.

<table>
<thead>
<tr>
<th>Angle of slope β, degrees</th>
<th>0</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value of the coefficient C</td>
<td>1.00</td>
<td>0.90</td>
<td>0.80</td>
<td>0.70</td>
<td>0.65</td>
<td>0.58</td>
<td>0.52</td>
<td>0.48</td>
</tr>
</tbody>
</table>

$q = 47,1.[(D+2δ)^2 - d^2].S.K.n.p.C,$  (6)
$q = 47,1.[D^2 - d^2].S.K.n.p.C,$  (7)
$q = 47,1.D^2 S.K.n.p.C,$  (8)

where $D$ is the diameter of the auger, m;
$\delta$ - the radial gap between the periphery of the auger and the inner one surface of the auger housing, m;
$S$ - the auger step, m ($S = (0.8 ... 1.2) D$);
$K$ - the filling factor ($K = 0.8 ... 1.0$);
$n$ - rotational speed of the auger, s⁻¹;
$\gamma$ - the bulk density, $\mathrm{t/m}^3$;
$C$ - the coefficient that measures the angle of the slope $\beta$ to the horizon on the performance of the doser.

The performance of single-screw dispensers is determined by different expressions:

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The relative error of the device can be estimated by the coefficient of variation $V$:

$V = \pm \frac{100 \sigma}{Q},$  (5)

where $Q$ is the mean value of the doser's performance of samples, kg/s (m³/s).

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Table 1 gives adjustments to the performance of the dosator from the angle of inclination to the horizon.
Expression (6) shows the diameter of the auger, the shaft and the gap between the auger and the casing. Expression (7) does not account for the gap between the auger and the casing, while the expression (8) does not take into account the gap between the auger and the casing and also the shaft diameter.

For the forward calculations we will use an expression (7). The play has a more complex aspect of productivity, because in this space the speed of the material is different. We will set the minimum possible gap according to the technological capabilities of the device. We believe that dropping the diameter of the shaft is inadmissible. Not reading this constructive parameter will result in a significant constant dosing error.

The graphical performance dependency $Q$ is linear. Upon augmentation of auger rotation speed, productivity and power requirements are increased with the following dependencies:

$$Q = k_1 n, \text{t/h} \quad (9)$$

$$N = k_2 n, \text{kW} \quad (10)$$

The coefficient $k_1$ and $k_2$ are constant for each particular dispenser as performance is mainly governed by varying the screw rotation speed.

We determine the power of the dosator according to the formula (Owen, P. & Cleary, P., 2009):

$$N = \frac{Q}{367} (L_s \cdot W + H), \text{kW} \quad (11)$$

where $L_s$ is the horizontal projection of the material displacement path, m;

$H$ - height of material lifting, m;

$W$ - the experimental coefficient of motion resistance of the material along the canal.

The coefficient of motion resistance of the channel is determined by Table 2 (Owen, P. & Cleary, P., 2009):

<table>
<thead>
<tr>
<th>Material</th>
<th>W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry non-abrasive (cereal products, flour, sawdust, etc.)</td>
<td>1,2</td>
</tr>
<tr>
<td>Wet non-abrasive (sugar-refined, raw malt,)</td>
<td>1,2</td>
</tr>
<tr>
<td>Semi-abrasive (soda, coal, cooking salt)</td>
<td>2,5</td>
</tr>
<tr>
<td>Abrasive (gravel, sand, cement)</td>
<td>3,2</td>
</tr>
<tr>
<td>Highly abrasive and sticky (ash, molding, lime, sulfur)</td>
<td>4,0</td>
</tr>
</tbody>
</table>

The dose per revolution of the auger $Q_0$ is calculated using the formula:

$$Q_0 = 60 G n^2 t^{-1}, \text{t} \quad (12)$$

where $G$ is the weight of the feed collected by the dispenser in the collection volume, g;

$n$ - screw speed, min$^{-1}$;

$t$ - duration of the experiment, s.

The critical rotational speed of the auger $n$ is determined by:

$$n = 0.5 \pi \sqrt{\frac{g (\alpha + \phi_1)}{r \mu_k}}, \quad (13)$$

where $\alpha$ is the angle of helical lift;

$\mu_k$ - the coefficient of friction of the feed on the surface of the casing;

$r$ - the internal radius of the auger;

$$\phi_1 = \arctg \left( \frac{\mu_k}{\cos \theta} \right).$$

$\theta$ - the angle between the normal reaction on the surface of the auger and its axis. Detailed information on the friction coefficient of the feed on the surface of the casing can be found at: http://www.teleskopicheskie-pogruzchi.png/catalog/oobshie-svedenya/klassifikatsiya-i-harakteristika-gruzov.html

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The coefficients $k_1$ and $k_2$ are constant for each particular dispenser as performance is mainly governed by varying the screw rotation speed.

For the specific needs, it is advisable to use a screw dispenser, given the simple construction, relatively easy control, low value and high reliability.

The rotation rate for the particular application should be in the range of 10 ... 60 min$^{-1}$. Feed speeds above the upper limit lead to an increasing decrease in the filling factor and consequently a reduction in the volume efficiency of the auger. This means a larger error in the doser's operation between the calculated and the actual. It is also necessary to take into account the technological possibilities for implementing the construction parameters of the auger. It is also advisable to look for a minimum value of the gap between the diameter and the auger casing.

**REFERENCES**


Kellens, R., (2009). Optimizing dairy feeding programmes. Animal Science Department, Brigham Young University, Provo, Utah, USA.
