Transmission shaft and its parameters for feed choppers in agriculture

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Abstract. The article presents the results of research on the selection of a transmission shaft of an optimal design for a small-sized, simple-constructed crushing device and theoretical determination of its parameters. According to the analysis of rectangular, trapezoidal, oval, tubular and conical transmission rods, trapezoidal rods have an optimal construction. Such rods ensure the convenient transmission of the stalks to be crushed, as well as compression of the material from both sides, accumulation and transmission. For this reason, we adopt a trapezoidal transmission line to the blue stem feed shredder. Based on the results of the theoretical research of transmission rods, it was determined that the stalks transmitted from the rod to the crusher depend on the shape of the rod and some parameters. According to theoretical studies, in order to transfer the crushed feed to the device and its supply channels with a comfortable and low resistance, the length of its transfer chute should be 65 cm, the width of the front part of the chute should be 40 cm, the width of the part connected to the supply chute should be 20 cm, and the slope of the chute should be 27°.

1 Introduction

Currently, many different techniques and technologies are being developed to improve agriculture [1-3]. Among them, we can note the use of drones, combines and seeding units [4-9]. Shredders and mixers can also be considered one of such devices [10-14]. In grinding devices [11,14,15], the convenient transfer of the food to be crushed to the grinding machine largely depends on the transmission channel. If the shredder needs to have smaller performance and dimensions and be simpler in design, then the grinder needs a transmission shaft for manual feed [16]. In this regard, it is important to develop a conveyor belt with a convenient construction for the grinder, which is used in the grinding of blue-stem feeds in poultry, fishery and livestock farms, and which cuts the blue grass into the required size for each of their categories. Because the transmission rods are one of the main auxiliary parts of the shredder device, it consists of transferring the crushed stalk feed of different dimensions to the grinding machine without stops. In addition, the transfer bars should be convenient for the worker who throws the feed into the grinder. Otherwise, the worker's productivity will

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decrease and it will cause him to tire quickly. Based on that, we have analyzed the design of transmission lines used in combat equipment. At the moment, according to the shape of the construction of the existing feeding channels, channels such as quadrangular, trapezoidal, oval, turbular, conic are used.

The square shaped transfer bars are convenient to design and manufacture and to transfer the chopped feed to the grinder. But it is inconvenient to transfer nutrients that are not attached to them. Oval transfer bars are more convenient for feed transfer, but the ground feed is delivered to the chopper blades with an uneven surface. As a result, it affects the grinding quality. Tubular transfer bars are designed to transfer more dispersive materials. Therefore, the use of tubular transmission rods in the transmission of stalked feedstuffs leads to a decrease in productivity due to the fact that untethered stalks fall out of the pipe or get stuck in the pipe. Conical drive shafts greatly reduce these disadvantages of tubular drive shafts, but in them, like oval drive shafts, the ground feed enters the grinder blades with an uneven surface and causes uneven loading of the blades, that is, less on the edges and more on the middle. In addition, uneven grinding of stems also occurs in them. Trapezoidal rods have some acceptable constructions among transmission rods. Such rods ensure the convenient transmission of the stalks to be crushed, as well as compression of the material from both sides, accumulation and transmission. For this reason, we adopt a trapezoidal transmission line to the blue stem feed shredder.

2 Materials and methods

Analytical link, which allows to more accurately determine the cutting length of blue stem feed in drum grinding devices, was determined by mathematical analysis of the process of transferring stalks to cutting and grinding them in drum grinders, taking into account the parameters of the working parts of the grinding device that affect the cutting length.

When studying the parameters of the feeding channel to the grinding device, the thickness of the feed, the density of the feed being sent to the grinding device, and the longest and shortest length of the feed were determined.

GOST R ISO 11448-2002 "Portable shredders and crushers with automatic transmission" in determining the transmission of stalks during experiments. The methods given in the methodical manual "Work quality indicators and test methods" were used. Size-mass indicators and moisture content of crushed stems before experiments GOST 20915-2011 "Selskokhozyaystvennaya tekhniki. It was determined on the basis of "Metody opredeleniya uslovii ispytaniy".

Analytical methods were used, and other qualities of transmission lines were studied. According to the analysis, the upper part of the transmission channels was divided into open, closed and semi-closed types. Conveyors with an open upper part are convenient for conveying food, but some pieces of the stem thrown back in the grinder can hit the face and eyes of the employee passing the food and cause damage. Feeding troughs with a closed upper part are quite safe, but it is inconvenient to feed and feed them. From this point of view, it is appropriate to design a semi-closed overpass in this place.

Transmission rods, in turn, differ from each other in the material they are made of. In this case, they can be made of iron, aluminum or plastic material. It is more convenient and cheaper to make transmission rods from iron sheets. Their durability is also high. Making the drive rods out of aluminum or plastic keeps them light, but they wear out quickly with heavy use. Therefore, it is recommended that the transmission shaft be made of steel sheets.

3 Results and discussion

During the operation of the device, the blue stem feed is transferred to the feed trough and from it to the grinding drum through a rod. Since the shape and some parameters of the shaft that the food grinder conveys to the drum are directly related to the process of grinding food in the device, it is necessary to determine its main parameters depending on this process [17, 18].

Feed transfer and grinding process is affected by the shape of the trough, length Ln , width Vn and angle of inclination a_{uz}.

According to the analysis of the working process of the existing devices for manual feeding of stalked feed to the feed grinder, in order to facilitate the feed transfer, the width of the transmission channel should be wider at the beginning, narrowing towards the last part, and at the end, the grinding device should be able to pass the feed suitable for the work performance.

In that case, the shape of the transmission shaft can be taken in the form of a four-cornered prism with a large and small base (Fig. 1).

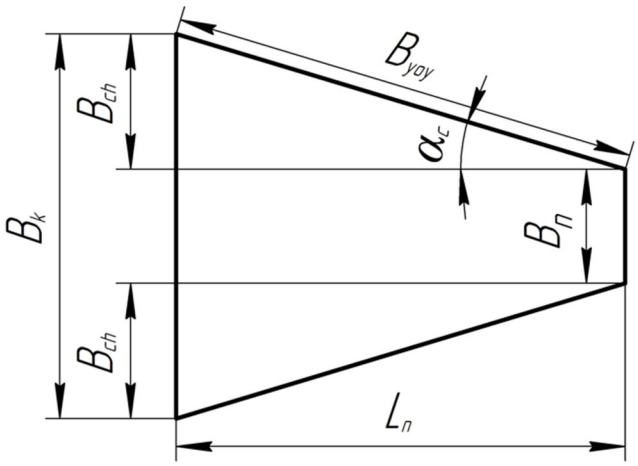


Fig. 1. Scheme for determining the dimensions of the transmission shaft.

The width of the front part of the trough

$$B_k = B_n + 2B_{ch} \tag{1}$$

where V_k is the width of the front part of the transmission channel, m;
V_n – the width of the last part of the transmission line, m;
B_{ch} – the width of the outer part of the transmission line, m.
According to the scheme in Figure 1

$$B_{ch} = L_n tg a_c \tag{2}$$

where L_n is the length of the transmission line, m;
a_c is the angle of inclination of the edge of the transmission channel, grad.
Then, taking into account the expression (2), the width of the front part of the beam

$$B_k = B_n + 2L_n tg a_c \tag{3}$$

In order to transfer the feed with low resistance to the feed grooves, the slope angle of the edge of the transmission shaft should be smaller than the friction angle of the feed. According to the scientific research data, taking into account that the minimum friction angle of corn and alfalfa stalks in the blue state is in the range, $\varphi_{min} = 25 - 28^{O}$ it is considered acceptable that the angle of friction of the transmission shaft should be $a_c = 25^{O.}$

We determine the length of the transmission shaft based on the length of the smallest stems in the stem feed being transferred to the grinder, i.e.

$$L_n \geq l_n^{min} \tag{4}$$

where l_n^{min}- the length of the smallest stems in the ground feed, m.

If $l_n^{min} = 62{,}4\ cm$so, the length of the transmission line should be 65 cm.

If this condition is met, it is ensured that even the smallest stems in the mass being transferred are transferred without falling.

Vn of the part of the transmission shaft that introduces the feed into the grinding device from the condition of delivering the feed to the device suitable for its performance, and it is as follows

$$B_n = \frac{q}{hpk_{uz}V_{uz}} \tag{5}$$

where q is the work output of the grinder, kg/s;

h - the thickness of the feed being sent to grinding, m;

r - the density of the feed sent to grinding, kg/m ^{3} ;

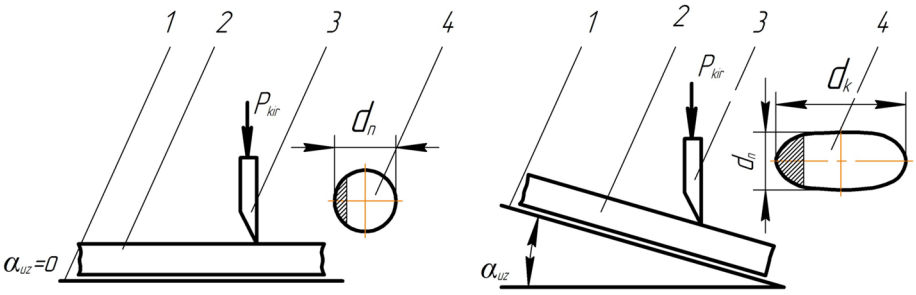
k_{uz} is a coefficient that takes into account the periodicity of feed transfer; k_{uz} = 0.5-0.8 when feed is transferred by hand.

B_{uz} – feed transfer speed, m/s.

If q =0.142 kg/s; h = 0.02 m; r = 118.2 kg/m ^{3} ; It turned out that if V_{uz} =0.44-0.5 m/s, then V_n =18.3-22.1 cm. For constructive convenience, we take V_n =20 cm.

Then V_n = 20 cm, L n = 65 cm, and taking into account that a_c = 8-10 ^{O} is acceptable for the transmission of feed with low resistance to the feeders and structurally convenient , according to the expression (3) the width of the front part of the transmission shaft is B It follows that $_{k = 38.2\text{-}43.4\ cm.}$ We take $B_{k=40\ cm.}$

Now we determine the angle of inclination of the transmission shaft. The inclination of the transfer bar directly affects the transfer of stalks to the blade and the cutting angle, and ultimately the resistance to cutting and the cutting length.



a - in the horizontal position; *b* -in the inclined position

1- transmission line; 2nd stem; 3rd blade; 4-stem diameter

Fig. 2. Schematic diagram of the state of transmission of stalks to shearing.

According to the 1st case, the cutting force is maximum when the stems are transferred horizontally to the blade or the blade is perpendicular to the stem, that is

$$a_{uz} = 0 \Longrightarrow P_{kir} = P_{max}. \quad (6)$$

In case 2, there are two different cases. In this case, if the angle of transmission of the rods is smaller than the angle of friction, the shearing force is smaller than the maximum value, but higher than the minimum value. If the angle of transfer of stems is greater than the angle of friction, the shear force is minimal, that is

$$a_{uz} < \varphi \text{when} \Longrightarrow P_{min} < P_{kir} = P_{max} \quad (7)$$

$$a_{uz} > \varphi \text{when} \Longrightarrow P_{kir} = P_{min} \quad (8)$$

where φ is the friction angle of the stems, degrees.

However $a_{uz} > \varphi$, the cross-sectional surface of the cut stem is elliptical **(Fig. 2** , b). For this reason, it is not allowed that the angle of transmission of the rods is too large than the angle of friction. If the reason $a_{uz} > \varphi$is, the large diameter of the elliptic cross-section of the stem may be greater than the cutting length specified by zootechnical requirements, $d_k > l_{kir}$i.e.

Therefore, in order to ensure that the crushed stalks are conveyed with as little friction as possible, the angle of inclination of the chute should be

$$a_{uz} > \varphi_{min} \quad (9)$$

we consider that $a_{uz} = 27^O$the minimum friction angle of corn and alfalfa stalks in the blue state is in the range, $\varphi_{min} = 25 - 28^O$it is reasonable to assume that the slope of the transmission shaft.

Based on the analyzes and theoretical studies, a grinding device with a convenient transmission channel was made (Fig. 3).

Fig. 3. A compact shredder with a convenient transmission channel.

This shredding device is currently used in small livestock, poultry and fish farms. During its use, there were no inconveniences and complaints among the employees who use it.

4 Conclusion

Conveyor bars are considered one of the important parts of the shredder device, and it should transfer the stalk feed, whether or not it is in the state and with different overall dimensions, to the crushing machine without any interruptions. In this respect, the trapezoidal rods are more convenient, and such rods provide a light transfer of the stalks to the shredder, as well

as compressing and collecting the material from both sides. For this reason, a trapezoidal transmission shaft design was chosen for the small-sized crusher. According to theoretical studies, in order to transfer the crushed feed to the device and its supply channels with a comfortable and low resistance, the length of its trapezoidal transfer chute should be 65 cm, the width of the front part of the chute should be 40 cm, the width of the part adjacent to the supply chute should be 20 cm, and the slope of the chute should be $27^{o.}$

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