BIO Web of Conferences **95**, 01023 (2024) https://doi.org/10.1051/bioconf/20249501023
CIBTA-III-2024

Results of the study of rotary feed pump with separator and screw feeder

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Abstract. The article presents the results of an analysis of experimental studies of a rotary lobe pump with a separator and a screw feeder. The pressure loss in the feed line, the influence of the shape of the separator and the angle between its working edges on the performance characteristics of the pump, the influence of the performance of the screw feeder on the characteristics of the pump and the influence of the rotation speed of the pump shaft on its characteristics are studied. characteristics. As a result of experimental studies, it was established that a rotary pump with a screw feeder reliably transports feed mixtures with grass paste with a moisture content of 74% or more and feed mixtures without grass with a moisture content of 68% or more at a pressure in the discharge line of 0.4 MPa. In this case, the speed of the feed mixture in the suction cavity of the pump must be at least 0.42 m/s, which is ensured by a screw feeder.

1 Introduction

Currently, many pig farms and complexes use concentrate feeding only. However, the insufficient quantity of these feeds and their high cost hinder the increase in pig production. The introduction of succulent or green feed into feed mixtures makes it possible to save concentrated feed and at the same time increases the biological value of diets [1-2]. However, the introduction of succulent or green feed into feed mixtures changes the physical and mechanical properties of feed mixtures, i.e. the fluidity of feed mixtures decreases several times. This makes it difficult to transport feed mixtures through pipes**.** To solve this problem, special feed injection pumps with high reliability are required. Solving this important problem, we have developed, manufactured and tested a rotary pump with a separator and a screw feeder [3].

2 Methods and materials

Experimental studies were carried out on an installation designed in such a way that it ensures the technological process of transporting and distributing feed mixtures through pipes in the production conditions of pig farms using pumping units and allows all planned

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experiments to be carried out to determine the optimal operational, technological and energy parameters of the pump being developed.

The experimental installation (Figure 1) consists of a rotary pump 1, a screw feeder 2, a steamer-mixer 3, a staple conveyor for feeding crushed juicy and green feed into the mixer 4, a grinder-paste preparation 5, a thermometer sensor 6, a tap for cold and hot water 7, 8, level gauge 9, pressure gauges 10, feed pipe 11, valve for adjusting the flow and pressure of the pump 12, measuring tank for determining the flow of the pump 13, fecal-mud pump FGS-50/12.5, hopper for receiving combiforms 15, screw conveyor 16, safety valve 17 and other measuring instruments [2]. The installation works as follows. First, the feed components are weighed according to the diet. Includes electrical wires for the pasta grinder, feed staple conveyor and mixer. Juicy feed (green mass) is crushed and fed into the mixer using a staple conveyor. According to zootechnical requirements, at least 80% of feed particles in the crushed product must be up to 5 mm in size. In this case, good transportation of feed mixtures through pipes and complete consumption of feed by animals is guaranteed. To supply water, a cold and hot water supply 15 is connected to the mixer. To determine the level of feed mixtures, a level gauge 16 is installed on the mixer in the form of a glass tube with a scale [3].

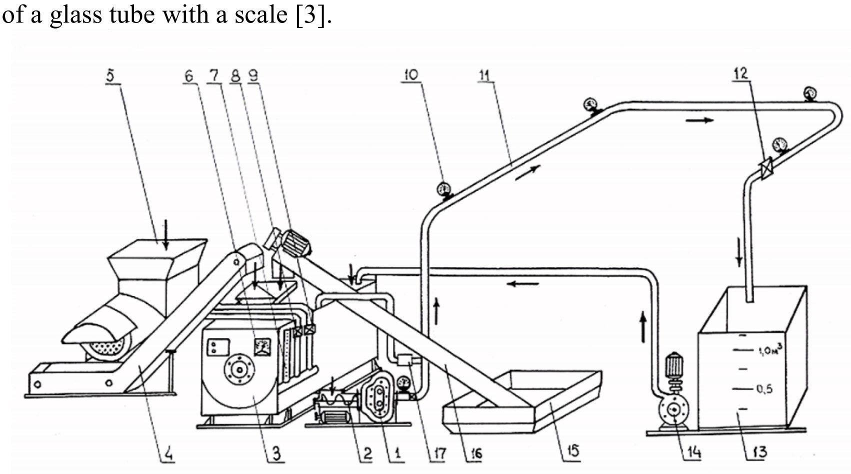

Fig. 1. Experimental setup diagram.

Here 1-rotor pump (tested); 2-screw feeder; 3-steamer mixer; 4-conveyor; 5-chopper paste preparation; 6-thermometer sensor; 7-level; 8.9-faucet for cold and hot water; 10-pressure gauge; 11-feed line; 12-valve "Ludlo"; 13-dimensional tank; 14-fecal pump; 15-bin for mixed feed; 16-screw conveyor; 17-safety valve.

After 15 minutes of mixing, samples are taken from the mixer inspection hatch to determine the physical and mechanical properties of the feed mixtures. Repeat sampling at least three times. Then pump 12 is turned on and the finished feed mixture is pumped into the feed line and then into the measuring tank. The filling time of the measuring cup is determined by a stopwatch. The volume of the measuring tank is V=1.25 m3. At the same time, the pump drive power is recorded using an N-396 recorder and the pressure in the discharge line. After determining the flow, required power and pressure created by the pump, the fecal pump 9 is turned on and the feed mixture is pumped into the mixer. This allows for repeatability of the experiment.

To equalize the pressure in the feed line, the pump is equipped with a safety valve 11. If there is excess pressure in the feed line, the valve is activated and the pump is switched on for recirculation. The rotation speed of the pump rotors and propeller is controlled by five replaceable sprockets. In addition, the installation was equipped with measuring instruments: a self-recording device N-396 for recording the required power, pressure gauges for determining the pressure in the feed line, platform scales for weighing feed mixture components, laboratory scales for weighing selected samples, a measuring tank for determining pump flow, a drying cabinet for determining humidity and concentration of feed mixtures, thermometer, stopwatch and other instruments [4].

3 Results and Discussions

The research results show that the pump supply with a decrease in humidity initially, to approximately 68.0% humidity for the concentrate diet, 74.0% for feed mixtures with grass paste and 72% for feed mixtures with a concentrated root diet, and then sharply decreases. With a further increase in the humidity of concentrate diet feed mixtures to more than 75% by diluting it with water, the pump flow is reduced. This is explained by an increase in pressure losses inside the pump due to an increase in leakage from the discharge chamber to the suction chamber through the gaps. Pressure loss in the feed line consists of two components: pressure loss along the length and local losses [4-5].

As a result of the research, additional data were obtained on linear pressure losses depending on the composition of mixtures and pump flow.

In Figure 2 shows the dependence characterizing the change in pressure loss in pipes with pump supply and humidity of feed mixtures. These data show that pressure losses at the same humidity, but for different concentrations of feed mixtures, are not the same. From this we can conclude that it is advisable to evaluate the performance of pumps by the concentration of transported feed mixtures, and not by humidity [6].

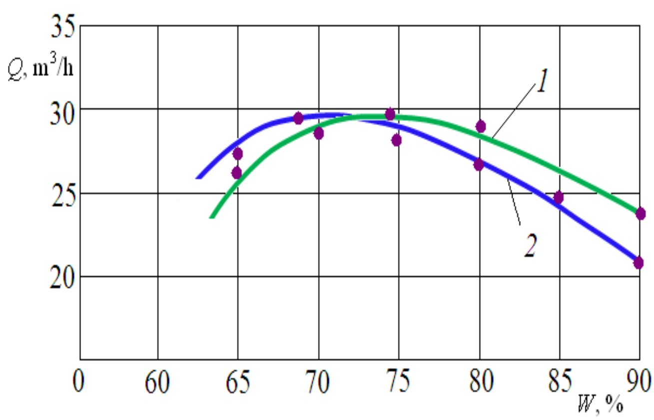

Fig. 2. Dependence of the supply of the lobe pump on the moisture content of feed mixtures**,** 1-feed mixture with grass paste; 2- feed mixture of concentrated-root type.

The increase in pressure losses with increasing concentration of feed mixtures is explained by the fact that when such feed mixtures flow through pipes, most of the solid particles accumulate in the lower part of the pipeline. This leads to an increase in pressure losses in the pipeline and to a decrease in the flow and speed of feed mixtures in the pipeline. In addition, the increase in losses is caused by friction between the liquid phase and solid particles of feed, as well as friction of solid particles of feed against the walls of the pipeline [7].

The influence of the shape of the separator and the angle between its working edges on the performance characteristics of the pump. To select a rational separator shape, the pump was equipped with three replaceable separators: flat, convex and wedge-shaped. The data obtained showed that the type of separator changes the shape and dimensions of the pump suction chamber and significantly affects the pump performance.

Research shows that with a productivity of 30 m³/h the required power of a pump with a wedge-shaped separator is 4.82 kW. When using a flat and convex separator, the required pump power is 5.12 and 5.18 kW, respectively. At the same rotor speed, the flow rate of a pump with a wedge-shaped separator is slightly higher than with a convex separator. This is explained by the fact that the use of a convex separator leads to a decrease in the cross-sectional area of the pump inlet neck, and the filling factor of the working chambers of the pump decreases accordingly.

To determine the effect of the angle between the working surfaces of the separator on the required pump power, experimental studies were carried out with separators at different angle values [8].

In this case, the angle was 60^0, 80^0, 100^0, 120°. The research results are shown in Figure 3. The study showed that the most effective is a wedge-shaped separator at angle values of 90...100°. Thanks to the optimal arrangement of the flat edges of the dividers, for example 100°, each individual feed flow is directed to the corresponding rotor, i.e. directly on the blade.

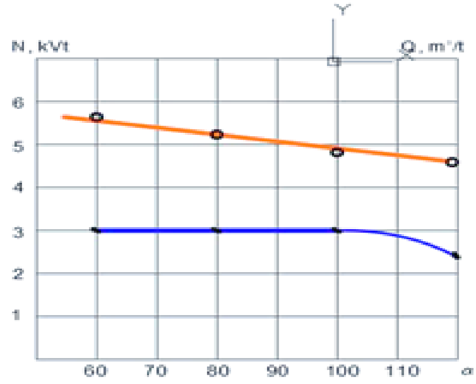

Fig. 3. Dependence of productivity (Q) and required power (N) from the angle between working edges of the separator.

However, increasing the angle above 100^0 leads to a decrease in pump flow. This can be explained by the fact that as the angle increases above 100^0, the cross-sectional area of the suction pipe decreases [9].

Influence of screw feeder performance on pump characteristics. The results of the experiments showed that one of the bottlenecks limiting the ability of rotary pumps to operate on feed mixtures of high concentration; is the low suction capacity of the pump, i.e. the design of the pump suction pipe, where an increase in resistance with an increase in the concentration of feed mixtures causes failure of the operating mode and cavitation. Thus, the deterioration of the conditions for the entry of feed mixtures into the pump is the main cause of cavitation. Therefore, a great reserve for increasing the technological performance of pumps is to provide conditions that facilitate the flow of feed mixtures into the pump.

To solve this issue, we used a screw feeder installed in front of the suction pipes of the pump. The performance of the screw feeder was regulated by changing the rotation speed of its screw using replaceable sprockets [10].

The research results (Figure 4) showed that the influence of the screw feeder supply on the pump performance increases along with a decrease in the moisture content of the feed mixtures. Research has established that the productivity of a screw feeder decreases when feeding feed mixtures with a moisture content of more than 80% has little effect on pump performance.

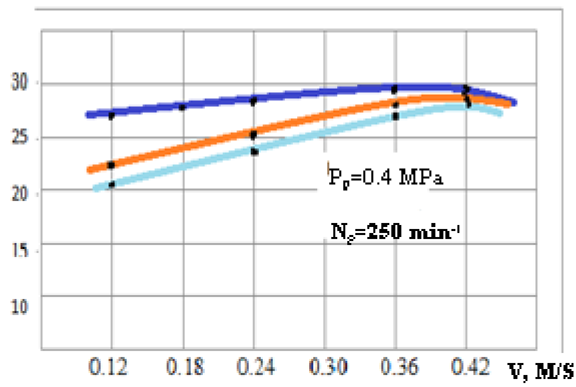

Fig. 4. Dependence of the flow rate (Q_p) of the pump on the speed of feed mixtures (v) in the suction pipe of the pump.

However, with a decrease in the humidity of feed mixtures below 80% and a change in its fractional composition at such a feeder productivity, the pump flow is reduced by 18...20%. This is explained by the fact that low-humidity feed mixtures have fairly high viscoplastic properties, which lead to a decrease in the speed in the suction line by 3...4 times. In this case, the feed mixture does not have time to fill the working chamber of the pump, and therefore the efficiency decreases and pump delivery [11-16].

Influence of pump shaft rotation speed on its characteristics. Changing the pump rotor speed during testing from 300 to 400 min-1 did not have a noticeable effect on the nature of the change in overall efficiency. Highest efficiency pump (μ=0.64) when feeding concentrate type feed mixtures with a moisture content of 68% was obtained at a pressure in the discharge line of 0.4 MPa and a pump shaft rotation speed of 350 min –I, and when feeding feed mixtures with grass paste μ = 0.58. The lower performance of the pump when pumping a feed mixture with paste made from St. grass is due to the fact that such a feed mixture has the ability to absorb moisture, turning into less fluid, while simultaneously increasing the moisture content in the feed mixture.

Research to obtain pump characteristics was carried out on two types of feed mixtures, the composition of which is given in Table 1.

Table 1. Pump characteristics.

No.	Composition of feed mixtures	Feed ratio per 1 kg of feed	Humidity, %	Viscosity, Pa. s	Density, kg/m^3
1	Compound feed + water+ grass paste	1:3:0.4	74	1,43	1050
2	Feed+water	1:2	68	0,90	1121

Analysis of the research results shows that the pump flow rate decreases with increasing pressure, and the required pump power increases (Figure 5). When feeding feed mixtures No. 1 with an increase in pressure in the discharge line to 0.6 MPa, the pump flow decreases by 22%, and the required power increases by 32%, and when feeding feed mixtures No.2, the pump flow decreases by 18%, power increases by 25.5%. There is also a decrease in efficiency pump when pumping feed mixtures No. I and No. 2 with a pressure increase of more than 0.4 MPa in the discharge line. Thus, for feed mixture No.I, the maximum efficiency is μ=0.68 and for feed mixture No.2 μ=0.64.

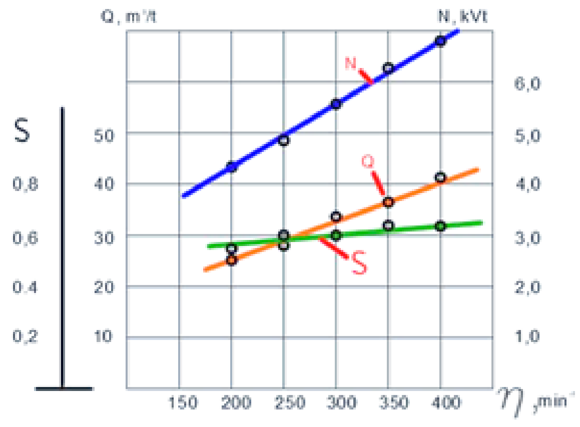

Fig. 5. Dependence of main parameters pump (Q, N, μ) on the rotor speed (n) at pumping feed mixture No. 1.

When comparing the influence of discharge pressure and the productivity of the screw feeder on the pump flow, a significant decrease is observed in both the first and second cases. Thus, with an increase in discharge pressure to 0.6 MPa, the pump flow decreased by 22% when feeding feed mixtures No. I. And due to a decrease in the productivity of the screw feeder to 15 m^3/h, it decreased by 18...20%. In the first case, such a decrease is explained by the fact that with an increase in pressure in the discharge line, leaks from the discharge cavity of the pump into the suction chamber increase; in the second case, due to a decrease in the supply of the screw feeder, a sufficient amount of feed mixture does not enter the pump, and it operates at an incomplete load. It should be noted that in the first case, the required power for the pump increases, and in the second case it decreases due to the separator installed in the pump.

4 Conclusions

Thus, as a result of the experimental studies, the following was established:

- A rotary pump with a screw feeder reliably transports feed mixtures with grass paste with a moisture content of 74% or more and feed mixtures without grass with a moisture content of 60% or more at a pressure in the discharge line of 0.4 MPa. In this case, the speed of the feed in the suction cavity of the pump must be at least 0.42 m/s, which is ensured by a screw feeder;
- As the discharge pressure increases, volumetric losses proportionally increase, reducing the pump flow;
- When the humidity of feed mixtures increases to 74% or more, volumetric losses increase depending on the gaps between the rotor and the pump housing, so the pump flow decreases.

With an increase in the concentration and viscosity of feed mixtures, leakage through gaps is significantly reduced to a value that is not taken into account in the calculations.

When feeding feed mixtures of increased concentration with a change in the rotation speed of the pump rotor, volumetric losses change slightly.

Efficiency the pump increases with increasing discharge pressure, but does not change so noticeably with a change in the pump rotor speed.

The required pump power increases with increasing flow rate, discharge pressure and viscosity of feed mixtures.

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