Application of the information measuring system to improve the feeding mechanism of a roller machine

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Abstract. The article describes principles of using the information measuring system that controls a roller machine. The main indicators of efficiency of a roller machine are performance and product quality. A mechanism for feeding the roller mill is crucial when grinding grain. Automatic regulation of technical parameters of the feeding mechanism of roller machines is advisable: at low peripheral speed rates (up to 2.4-2.8 m/s) - by changing the number of revolutions of feeding rollers or the gap value; at high peripheral speed rates (2.4-2.8 m/s) - by changing the values.

1. Introduction

One of the main parameters of a roller machine is its performance. The task of maximizing performance while maintaining the product quality is relevant. The feed of roller mills is crucial. However, modern feeding mechanisms are not able to provide high-speed product feed and increase performance of roller mills.

This paper discusses principles of operation of feeding mechanisms of roller machines and attempts to develop a more advanced feeding mechanism that meets requirements of high-quality and productive operation of mills.

Feeding mechanisms of roller machines are divided into the following types: two-roller, one-roller and shaking ones. The first type is used in machines manufactured in Russia; it is the most common in European roller machines. The second and third types are used mainly in American machines.

The two-roller feeding mechanism works as follows: a product entering a receiving bucket of the roller machine is captured by an upper feeding roller and transferred to the lower one which aligns it into a thin line and transfers it to a slowly rotating work roll. The rollers rotate at different speeds: the upper one has a smaller number of revolutions compared to the lower ones. The amount of products supplied to the grinding zone of work shafts is regulated at the upper feed roller by a damper.

The product from the receiving bucket is captured by a rotating threaded feed roller fed to the grinding zone of the rolls. The amount of products is regulated by a flap. The feed of the product in this feeding mechanism is less uniform than in the two-roller one.

The shaking feeding mechanism is well-known. The product from the receiving bucket falls on an inclined oscillating plane which is driven in a rectilinear return movement from the eccentric.

The amount of output products is regulated by approaching or removing a shield from the inclined oscillating plane. The shaking feeding mechanism has an advantage over the roller mechanism, since it consumes less energy. This mechanism ensures a uniform feed of the machine zone. But it is unsatisfactory in terms of its dynamics.
The influence of feeding mechanisms on the performance of roller machines should be considered on the example of roller feeding mechanisms. Feed rollers are driven by rolls. With an increase in peripheral speeds of the latter, peripheral speeds of feed rollers also increase.

According to P.A. Kozmin, due to the improvement of roller machines and an increase in peripheral speeds of their rolls from 1.5 to 7.2 m/s, changes in peripheral speeds of feed rollers were observed in the range from 0.125 to 0.785 m/s. In our roller machine operating at high speeds (6 m/s), feed rollers have circumferential speeds: the upper ones - 0.15 m/s, the lower ones - 0.55 m/s. It is characteristic that in the area of power supply of roller machines, there was a trend to increase speeds of the feed rollers; these speeds were reduced to 0.785 m/s (for the lower roller), but then despite a further increase in the peripheral speeds, this speed decreased up to 0.55 m/s. This speed is optimal [1, 2].

The optimal peripheral speed of 0.55 m/s was confirmed in the work by G Levyatin and L Fidelman. The authors note that at a speed of 4.5 m/s and a gear ratio of 2.5, the speed of the feed roller in the roller machines of the Bueller system was 0.41 m/s; the final speed of the product particle which is a sum of the initial speed of the feed roller and the speed of the product particle with its free fall on the way between the feed roller and the work roller, was equal to 1.81 m/s, i.e. it corresponded to the speed of a slowly rotating work roll. Our designers were guided by the same considerations when creating a roller machine according to the old model.

However, when increasing the speed to 6 m/s while maintaining the parameters of the feeding mechanism, the final speed of the particle does not correspond to the speed of a slowly rotating work roll. On the basis of theoretical calculations, these authors concluded that for an existing type of feeders, the maximum number of revolutions (to avoid detachment of a product particle) for the feed roller will be 154 rpm which corresponds to the maximum peripheral speed 0.6 m/s.

In the applied designs of the feeding mechanism of a roller type, it is impossible to increase the speed of feeding rollers above 0.55 m/s [3-5].

The use of increased circumferential speeds of work rolls (6 m/s) makes it possible to increase performance of the roller mill. But these capabilities are not used, since the power supply mechanism in its modern form is not able to load a roller mill in accordance with its increased performance.

The lower supply roller is not taken into account in calculating performance, since its role is reduced to leveling the product coming from the upper roller.

The estimated performance of work rolls is 3.5 times more than the normal performance of roller machines. This makes it possible to increase performance of roller machines.

At the same time, the calculation reveals limited capabilities of the feeding mechanism - the performance of the feed roller is 3 times less than the performance of work rolls of the roller machine. Hence, it is necessary to improve the power supply of roller machines. In improving this device, it is necessary to create fundamentally new designs of feeding mechanisms which will correspond to the increased performance of roller machines and ensure the proper product flow while bridging the gap between the final product speed and the speed of a slowly rotating work roll.

Roller machines are produced in Switzerland, Germany and France. Their feeding mechanism is sensitive and accurately regulates the automatic power control. The amount of products fed to the work roll is automatically controlled by changing the slot and the number of revolutions of the feed roller.

But even in these significantly improved power supply mechanisms, the main task associated with an increase in their performance has not been solved [6].

2. Materials and methods for conducting experiments
The following questions issues were solved:
- whether the rapidly rotating rifles of feeding rollers are able to overcome the inertia of the product, since the capture of particles must be ensured under the worst conditions, i.e. when the rapidly running rifles of the feeding roller must capture the particle of the product whose speed is zero (the speed of a particle before its capture is zero);
- the influence of high peripheral speed of feed rollers on the product density;
- the dependence of performance of work rolls on the peripheral speed of feed rollers and the size of
the gap between them;
- the possibility of using the feeder for the coarsest products with low bulk density;
- comparison of the theoretical performance with the actual one;
- calculation of practical filling factors.

The feeder is a frame with a bucket and rollers in the upper part. Roller bearings are movable, which makes it possible to adjust the distance between them.

To observe the behavior of the product and the operation of rollers, two opposite sides of the upper part of the bucket (from the end parts of the rollers) are protected with safety glass.

Sizes of rollers: the diameter is 100 mm, the length is 200 mm. The surface of feed rollers is cut with a trapezoidal shape flute.

To ensure a better grip and even supply of the product, the riffles are positioned obliquely with respect to the generatrix by 2.5%. The flute dimensions and their number remained unchanged.

The feeder was driven by an electric motor through two counter-drives with stepped pulleys. Inter-roller movement was determined by grooves and a belt of circular cross section.

The number of revolutions of rollers was pre-set using a rev counter, followed by a control check at the start-up of the product sample.

Measurement of the clearance. To determine the exact size of the gap between the rollers, probes were made. By means of probes, four different gaps were set: 2, 4, 6 and 8 mm.

After determining the distance between the rollers, the product was passed through the feeder without control, after which the feeder was stopped, and the gap was checked with a feeler gauge along the entire length. Deviations were eliminated.

In order to obtain intermediate products, grain was grounded.

Characteristic grain. Saratovskaya 42 spring wheat, a mixture of powdery and semi-vitreous grain, natural weight of 821 g, humidity of 14.7%.

Grinding characteristics. 100 kg of grain. The grinding was performed by five ragged systems. For each system, a certain gap was determined using a probe from a set of metal blades.

3. Test method

The parallelism of the gap between feed rollers was determined using a probe. After pre-skipping the product, the feeder stopped to re-check the size of the gap. With the final pass of the product, the number of revolutions of the feed rollers was measured. The weight of the product was 2 kg with the exception of the upper gathering from the fifth ragged system which was 1.87 kg.

The performance of feeder Q was set using the stopwatch when the products were skipped by the feeder with the following variables:
- the number of revolutions of the feed rollers which determine peripheral speed \( V \);  
- the distance between the feed rollers which determines the rank of gap \( N \).

Volumetric performance of the feeding mechanism depends on the working volume of the threaded feed rollers. Both rollers of the feeding mechanism rotate at the same speed. Assuming that the product jet emerges from the inter roller space with the peripheral speed of the feeding rollers, it is possible to obtain the volume filled with the product. The working volume of the threaded rollers consists of two parts: the internal working volume, i.e. the volume of the recesses between the grooves on each roller, and the external working volume depending on the removal of the rollers from each other.

For the operation of this information-measuring system that controls the operation of the feeding mechanism of the roller machine, the authors have developed software for assessing the quality of grain processing industry products using grain analysis results” (the certificate No. 2016660501 of September 16, 2016); software for the compilation of grinding batches with specified properties (the certificate No. 2017660454 of September 21, 2017); software for determining milling properties of grain (the certificate No. 2018610816 of January 17, 2018).

The general view of the structure of this information-measuring system is presented in Figure 1.
Figure 1. The generalized block diagram of an information measuring system for determining consumer properties of grain: 1 - measuring devices; 2 - analog-digital converter; 3 - information processing subsystem; 4 - subsystem for displaying information about consumer properties; 5 – consumer of information.

The basic element of the information-measuring system can be presented as follows (Figure 2).

Figure 2. The structural diagram of organization of the element of the information-measuring system that controls the feeding mechanism.

4. Test results
A device used for power supply of rollers which has a special accelerating mechanism consisting of two endless ribbons in combination with single roll feeding was tested.

The product fed through the receiving bucket and the single-roller feeder in the wedge-shaped space between the belts of the accelerating feeding mechanism has greater speed. At this speed, the product is thrown into the grinding zone of the roller mill. Unfortunately, the department does not provide technical data that would characterize the work of a new power supply mechanism and its impact on the grinding process.

The overclocking mechanism is able to ensure a high speed of the product, this mechanism is cumbersome and complicated.

The second part of the machine is occupied by the contours of the feeder. Consequently, for the equipment with accelerating mechanisms of a four-shaft roller machine, it will be necessary to increase the width twice. Each belt has two drums. For constant tension of the belt, it will be necessary to make one of the drums movable.

The overclocking mechanism is made by analogy with a grain console. It consists of two drums through which the endless belt passes. The drum is pressed to the belt. It has flanges of 5 mm in height. The grain from the receiving funnel enters the rapidly moving belt; falling into the gap between surfaces of the belt and the pressure drum, it is pressed against the belt and ejected as a fan-shaped stream to a distance of 10 m or more depending on the angle of inclination of the belt to the horizon.

The grain machine has the following technical characteristics: the belt speed is about 7 m/s; the speed of the drive drum is 1440 per minute; performance is about 25 t/h.

In the overclocking mechanism, the push bar of the grain panel is replaced with an endless belt. The
feeding rollers with a naped surface rotating at the same speed towards each other (according to the principle of working rolls), grip the product from the receiving bucket along the entire length and send it as a continuous jet directly to the inter-roll space. The product leaves the feeder at the speed of the feed rollers. At the time of entry of its particles into the grinding zone, the final speed of the product is a sum of the circumferential speed of feed rollers and the speed obtained during a free fall (under the gravity) from a height equal to the distance between the horizontal lines passing through the centers of the feed and working bodies.

By varying the number of revolutions and the size of the gap of the feeding rollers, regulation of the performance is achieved within wide limits.

The data are presented in Figure 3. The graph shows the dependence of performance on the peripheral speed of feed rollers. Performance is given in grams per 1 cm of feed roller length per second. Within the circumferential speeds of the feed rollers from 2.8 to 5.5 m/s, a large load was recorded at the circumferential speed of 2.8 m/s and a smaller load was recorded at the speed of 5.5 m/s. Performance increases within the speed range from 0.6 m/s to 2.4 m/s (it was not possible to determine the exact maximum peripheral speed experimentally). Then it gradually decreases.

For products, the highest capacity of the feeder with the same peripheral speed is set for the grain, the smallest - for the top run-off from the fifth grinded system. The performance of the feeder for the rest of products is far from large deviations.

The lower performance of the feeding mechanism corresponds to a gap of 2 mm; as it increases, performance increases. The highest performance is characterized by a gap of 8 mm. With the same gap size, the highest grain yield is higher for grain, and the lowest – for the upper gatherings of the fifth grinded system.

![Figure 3. The graph showing the influence of the peripheral speed of the feed rollers for grain (m/s) and the size of the gap between them (in mm) on the performance of the roller machine (g/s).](image)

5. Conclusion
Based on the results obtained, we can draw the following conclusions.

The use of feedback through the use of the information-measuring system helped improve the performance of the feeding mechanism.

The performance increases with an increase in the peripheral speed of the feed rollers to 2.4-2.8 m/s. With a further increase in peripheral speed, performance decreases. The performance depends on the size of the gap between feeding rollers. The degree of filling of the working volume of feed rollers is higher with a larger gap. With an increase in peripheral speeds from 2.8 to 5.5 m/s, the degree of filling decreases.
The rifles of feed rollers are able to overcome the inertia of the product at high speeds, when the speed of the particle before its capture by grooves is zero. It can be assumed that even without a feeder, the work rolls are able to grab the product and pull it into the grinding zone. The use of the feeding mechanism is possible for the coarsest products (grain) with the smallest volumetric weight while maintaining the flute number and profile.

Automatic power control is advisable to carry out at low circumferential speeds (up to 2.4-2.8 m/s depending on the product) by changing the number of revolutions or the gap size); at high peripheral velocities (2.4-2.8 m/s) - by changing the gap size.

This work was carried out in a laboratory and needs to be tested under production conditions.

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