Research of the rotation frequency of the working parts of an auger cleaner

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Abstract. The paper presents the results of a study of the working parts of a screw intended for transportation, drying, and cleaning of raw cotton at high productivity. The problem of the dynamics of a machine unit with a mechanism of camshafts in distribution devices of raw cotton during their storage has been solved and an analytical form of the law of changes in the technological load on the camshafts has been obtained, taking into account the results of experimental studies. An oscillogram of the camshaft at idle speed was experimentally obtained. Using the calibration of the measuring channel and the calibration coefficient was determined from the calibration graph, also used the fast Fourier transform method and converted the resulting amplitude value into current units of “ampere”, changes in the power of the electric motor of the shaft, cam, and screw for idle speed were obtained in the form of a graph and the value was determined torque of the electric motor equal to \( M_e=0.91 \text{ N-m} \).

1 Introduction

To transport, dry, and clean raw cotton at high productivity, we have developed devices with a screw conveyor mechanism; we conducted a whole experimental study on a bench installation.

The installation is designed to measure the load characteristics of the distributor at various capacities. Measurements are carried out simultaneously on two parameters - the speed of rotation of the distributor screw and the consumed electrical power (Fig. 1 a, b).

The distributor shaft rotation speed is measured using a photoelectronic sensor, the diagram of which is shown in Fig. 2.

The photoelectronic sensor consists of a light sensor (photodiode FD-256), a chopper disk (a disk with slots mounted on the screw shaft), and a light source (an ultra-bright red LED). When the screw shaft and, accordingly, the chopper disk rotates, the luminous flux from the light source to the photosensor is modulated with a frequency that is a multiple of the shaft rotation frequency [1].

In this work, disk 1 with a diameter of 150 mm made of acrylic plastic was used (Fig. 2), in which radial slots were made with a width of 5 mm and a rotation angle of 10, for 36 slots. Thus, the frequency of the received signal from the photosensor is 36 times greater than the...
rotational speed of the electric motor, expressed in revolutions per second [2]. To obtain the measurement result in revolutions per minute, the formula \( n = \frac{f \times 60}{36} \) is used, where \( f \) is the frequency of the signal from the photosensor in hertz.

A personal computer (Lenovo Legion Tower 5i) is used as a measuring device. The photo sensor 2 signal is sent to the right channel of the PC sound card. A specially developed program in Python 2.5 reads data from the analog-to-digital converter (ADC) of the sound card (conversion with a frequency of 8 kHz, 16 bits, stereo). Since the photosensor has a high output impedance, is connected to the computer via a relatively long cable (1.5 m), and measurements are carried out at a high level of electrical interference and vibration of the operating shaft, the signal from the photosensor is very noisy [3]. Therefore, when analyzing data received from an ADC, threshold cutoff is used, in which only signals with an amplitude greater than a certain preset threshold value are passed, and all other signals are cut off (equated to zero).

2 Materials and methods

To determine the frequency of the purified signal obtained in this way, the signal is counted by the number of signal transitions through zero and this number is divided by 2. This ends the measurement cycle. About 8 such cycles are carried out per second, and the results are recorded in a file and displayed in real-time. Since digital recording and data analysis are used, the rotation speed measurement error is no more than 1%.

Fig. 1. Experimental setup.

Simultaneously with the display of information about the rotation speed, the display also displays information about the current strength in one winding of the electric motor [4].

For this, a current sensor is used, which is a transformer, the primary winding of which contains 4 turns of enameled copper wire with a diameter of 2 mm and is connected to an open circuit of one of the windings. The current flowing through the winding of the electric motor and, accordingly, through the primary winding of the transformer induces the secondary winding (approximately 100 turns of enameled copper wire with a diameter of 0.5 mm, selected experimentally so that the signal value does not exceed 200 mV) a signal with the frequency of the mains and amplitude proportional to the current in the primary winding, which in turn is proportional to the power consumption of the electric motor.
The signal from this sensor is input to the second channel of the sound card, but at the same time, to reduce interference from the main supply, it is loaded into a resistance of 100 Ohms. The data obtained from the ADC is processed by the fast Fourier transform method, after which the frequencies closest to the mains frequency (50 Hz) are isolated from the resulting spectrum, and the amplitude of this component is determined. To convert the resulting amplitude value into ampere current units, a single calibration using an ammeter or wattmeter is required. The error in determining the current does not exceed 2% [5].

Now we determine the changes in electric motor power for idle speed. This requires information about changes in current strength in one winding of the electric motor. Sensor 3 (Fig. 2), representing a transformer (Fig. 3), transmits signals not exceeding 200 mV to the ADC and is converted to analog.

It should be noted that the starting torque of the electric motor is 10-15% greater than the rated one. After some time, the electric motor operates at a minimum dynamic load (Fig. 4).
3 Results and discussion

And also, based on the results of computer-processed data, it was established that an increase in productivity also leads to a decrease in the rotation speed of the screw shaft according to a nonlinear pattern [6]. With an increase in productivity to 3 t/h, the screw shaft rotation speed decreases to 98 rpm (10%) (Fig. 5).

![Fig. 5. The pattern of reducing the rotation speed of the screw shaft (auger) from a productive device.](image)

Fig. 6. Dependences of changes in the unevenness of the angular velocity of the propeller shaft on the performance of the machine, where, 1 – experimental; and 2 – theoretical.

![Fig. 6. Dependences of changes in the unevenness of the angular velocity of the propeller shaft on the performance of the machine, where, 1 – experimental; and 2 – theoretical.](image)

In addition, a comparison of the experimental results with the theoretical ones in determining the coefficient of unevenness of oscillations of the angular velocity of the propeller shaft also shows an insignificant difference. Figure 6 shows comparative graphical dependences of the unevenness of the angular velocity of the propeller shaft [7]. Analysis of the dependencies shows that the difference between the theoretical and experimental curves increases with increasing productivity (see Fig. Curves 1,2). The maximum difference between the experimental and theoretical indicators is 0.065 at $P_d = 2.0 \text{tonnes/hour}$ 9.0%.

By measuring the corresponding ordinate, we determine the torque on the electric motor shaft at the idle speed of the device (Fig. 4).

Then the moment the camshaft is
We compare the obtained data with the oscillogram obtained during the experiment.

\[ M_{\text{Cam}} = M_{\text{Elecmat}} \cdot i_{\text{belt}} \cdot i_{\text{Gearbox}} = 0.91 \cdot 3 \cdot 80 = 218 \, n \cdot m \]

Fig. 7. Calibration chart for idle speed of auger shaft.

First, we calibrate the measuring channel and from the calibration graph determine the coefficient of the measuring channel arising from the influence of the dynamometer (Fig. 7). The magnitude of the moment acting on the camshaft is determined from the oscillographic recording by the ordinate method (Fig. 8).

Multiplying the resulting ordinate by the coefficient of the measuring channel, we determine the torque acting on the camshaft at idle. This amounts to \( M_{\text{Cam}}^0 = 221N \cdot m \). By comparing the data obtained, we determine the measurement error

\[ \Delta = \frac{M_{\text{Cam}}^0 - M_{\text{Cam}}}{M_{\text{Cam}}^0} = \frac{221 - 218}{230} \cdot 100\% = 1.3\% \]

The measurement error is \( \Delta = 1.3\% \), which is acceptable.

In the same way, we determine the power of the electric motor rotating the propeller shaft. To do this, a diagram was obtained using a computer using the above method. The diagram is shown in figure 8.

By measuring the corresponding ordinates, we determine the torque on the electric motor shaft when the device is idling.

\[ M_{\text{tor}} = y_i \cdot k_m = 1.1 \cdot 0.43 \, n \cdot \frac{m}{mm} = 0.47n \cdot m \]

Then the moment the camshaft is

\[ M_{\text{Shaft}} = M_{\text{tor}} \cdot i_{\text{belt}} \cdot i_{\text{Gearbox}} = 0.47 \cdot 2 \cdot 3 = 2.83 \, n \cdot m \]

4 Conclusion

Regularities of changes in the rotation speed of the working bodies of the feeder-distributor using photoelectronic sensors and converters were obtained. A new technique for measuring
the rotation speed of the working parts of the feeder-distributor under various loads using photoelectronic sensors has been developed. The number of radial slots n=36 was determined. A special program was developed in Python, which reads data from an analog-to-digital converter (ADC), a sound card (conversion with a frequency of 8 kHz, 16 bits, stereo) and a diagram of the dependence of rotation speed on conveyor performance was obtained. An oscillogram of the cam shaft at idle speed was experimentally obtained. The measuring channel was calibrated and the calibration coefficient was determined from the calibration graph. Using the fast Fourier transform method and converting the obtained amplitude value into current units of “ampere”, changes in the power of the electric motor of the shaft, cam and screw for idle speed were obtained in the form of a graph and the value of the electric motor torque was determined $M_e = 0.91 \text{ N m}$, $M_k = 218 \text{ Nm}$. The measurement error was determined to be $\Delta = 1.3\%$.

References

1. K. Rakhmonov, S. Fayziev, M. Qodirov, A. Temirov, G. Toyirova, E3S Web of Conferences 390 06019 (2023)
2. Jamshid Sharipov, Akbar Abrorov, E3S Web of Conferences 417 06016 (2023)
3. Qadam Jumaniyazov, Oybek Xolmuratov, Fazliddin Egamberdiyev, Bobur Sharopov, E3S Web of Conferences 434 03031 (2023)