SELECTION AND VERIFICATION OF THE OVERLOAD CAPACITY OF AN ASYNCHRONOUS MOTOR FOR A FODDER SHREDDER

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Introduction. Fodder preparation is one of the production processes in farming, which is the most expensive in terms of energy consumption and the amount of labor, both manual and mechanized [1]. The classification of the equipment necessary for the mechanized preparation of fodder is carried out on the basis of the classification of the working bodies of the following machines: 1) knife shredders and mills, extruders, rotary and hammer crushers; 2) flatteners, roller crushers, grain mills; 3) granulators and briquetting machines; 4) mixers.

The operating conditions of fodder preparation mechanisms have their own specifics: non-linear growth of productivity and static resistance moment of the machine with growth with linear growth of movement speed (rotation), small values of starting moments (starting is usually carried out without load), long-term operation without speed regulation, and increasing load limited by a slight permissible decrease in speed during its growth, the equipment works in difficult environmental conditions (significant dustiness, significant limits of temperature and air humidity fluctuations).

The group of equipment for feed shredders (shredders) puts forward special requirements for the electric motors of its electric drive, due to the specifics of work [2]: significant power consumption and wide limits of its fluctuations during work, random nature of the load due to the heterogeneity of grain and grass mixtures, as well as manual loading, the need to control the feed load, significant coefficients of inertia of the system, low driving torque of working bodies, impossibility of starting with a full working chamber.

The productivity of machines for the production of fodder is determined not only by the energy consumption of production, but also by the quality of the manufactured fodder mixtures (absence of dust inclusion when grinding dry raw materials or pulp during processing of juicy raw materials). The main factor that determines the quality and productivity of feed grinders is the speed of rotation of the working body: both at low and too high speeds of rotation, the energy consumption of production increases, and the quality of the finished product decreases.

Therefore, electric motors for driving the working bodies of fodder shredders must provide a stable value of rotation speed in the range determined by the "productivity-quality" ratio, even without taking into account significant changes in the load on the shaft caused by manual loading. It is obvious that the required stability is provided by asynchronous motors with rigid mechanical characteristics.

The working bodies of feed shredders have a significant moment of inertia, so start-up usually takes place in a slow mode. In order to improve starting conditions, asynchronous motors with increased starting current are selected, and during starting, the stator winding is switched from "star" to "delta", which protects the motor windings from overheating due to high starting currents.

The aim of the work is to select an asynchronous motor for a feed grinder by power and check it according to the condition of overload capacity under initial conditions, which are the technical data of an industrial feed grinder: idle loss coefficient $X_0=1.15$ - 1.2; shredder productivity $Q=1.223$ *kg/s*; specific energy consumption for the production of one kilogram of product $q=28.8$ *kJ/kg*; Efficiency of the transmission mechanism, $\eta_n=0.9$.

Materials of research. The productivity of feed grinders, energy consumption and the quality of the final product largely depends on the type of raw material and its quality characteristics, such as the degree of heterogeneity and moisture, the average, minimum and maximum size of the element being ground. Considering this, when designing shredders, including when choosing an electric motor to drive the working body, it is worth considering the possibility of speed regulation, especially when it comes to universal equipment designed for processing all types of raw materials.

Approximate power of the engine for a feed grinder is determined by the formula

$$P=\frac{q\times X_0\times Q}{\eta_n}=\frac{28{,}8\times 1{,}15\times 1{,}223}{0{,}9}=45{,}006kW$$

Focusing on the power, we choose an asynchronous motor with an increased starting torque to reduce the heating of the motor during a long start 4АИРР180М4У2 with a power of 45 kW, a rotation frequency of 1455 rpm, η=0,92, cos φ=0,84, μ_S=2,0, μ_{min}=1,7, μ_s=3,0, multiplicity of starting current K_i=7,5, degree of protection IP54, constructive type IM1081.

Using the equivalent current method, we will process the experimentally obtained in [3] load diagram. For this, we replace the real load diagram with an equivalent one with trapezoidal sections, for each of which we determine the equivalent current

$$I_{E1}=\sqrt{\frac{45^2+45\times 70+70^2}{3}}=58{,}54A,\quad I_{E1}=\sqrt{\frac{43^2+43\times 72+72^2}{3}}=57{,}93A$$

$$I_{E1}=\sqrt{\frac{43^2+43\times 69+69^2}{3}}=57{,}23A,\quad I_{E1}=\sqrt{\frac{45^2+45\times 71+71^2}{3}}=59{,}02A$$

$$I_{E1}=\sqrt{\frac{44^2+44\times 73+73^2}{3}}=58{,}98A,\quad I_{E1}=\sqrt{\frac{45^2+45\times 70+70^2}{3}}=58{,}54A$$

$$I_{E1}=\sqrt{\frac{46^2+46\times 68+68^2}{3}}=59{,}31A,\quad I_{E1}=\sqrt{\frac{46^2+46\times 72+72^2}{3}}=59{,}97A$$

$$I_{E1}=\sqrt{\frac{45^2+45\times 69+69^2}{3}}=58{,}27A$$

Knowing the duration of the working periods, we determine the value of the equivalent current for a full working cycle

$$I_E=\sqrt{\frac{\begin{array}{l}3(58{,}54^2+58{,}98^2+59{,}31^2+58{,}27^2+57{,}23^2)+57{,}93^2\times 2{,}8+\\ 59{,}02^2\times 2{,}5+58{,}54^2\times 2{,}9+59{,}97^2\times 2{,}5\end{array}}{3+2{,}8+3+2{,}5+3+2{,}9+3+2{,}5+3}}=58{,}24A$$

According to the results of the determination of the equivalent current, we perform a check according to the thermal mode of operation $I_N \geq I_E$

$$I_N = \frac{45}{\sqrt{3} \times 0{,}38 \times 0{,}84 \times 0{,}92} = 65{,}7A$$

The presence of peak loads indicates the need to check the selected motor in terms of overload capacity

$$\mu_K \times M_N \geq M_{\max}$$

where μ_K=3,0 is multiple of the maximum engine torque, M_N is rated motor torque and M_N is maximum static torque on the electric motor shaft.

Rated torque of the selected motor is

$$M_N = 9550 \frac{P_N}{n_N} = 9550 \frac{45}{1455} = 228{,}7Nm$$

The maximum static torque on the electric motor shaft, determined by the load diagram

$$M_{\max} = \frac{\sqrt{3} U I_{\max} \cos\varphi\eta}{\omega_N} = \frac{\sqrt{3}380 \times 80 \times 0{,}84 \times 0{,}92}{152{,}2} = 265{,}7Nm$$

$$3 \times 228{,}77 \geq 265{,}7$$

The condition for checking the selected electric motor for overload capacity is fulfilled.

Conclusions. Based on the results of the calculations, the following conclusions can be made: 1) the choice of an electric motor for a universal feed grinder, designed for the processing of both wet and dry raw materials, taking into account manual loading and ensuring productivity of at least 4,5 tons per hour, was carried out by pre-determining the power necessary to meet the specified requirements, which is 45 kW; 2) the type of motor that will ensure a stable rotation frequency of the working body with significant changes in load is most expedient to choose an asynchronous; 3) while checking the selected motor according to the thermal mode during operation, the load chart data and the equivalent current method were used; 4) while checking the overload capacity, it was established that the maximum static torque on the electric motor shaft is less than the maximum torque of the selected motor, so the condition of overload capacity is completely fulfilled.

References

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