Impact Factor: 9.9 ISSN-L: 2544-980X

Algorithm of Energy Saving by Compensating the Reactive Power of Asynchronous Motors Used in Feed Grinding Devices

Abdullo Panoev [1], Makhsum Bozorov [2]

Abstract: This article provides information on the series and nominal values of three-phase asynchronous motors with a short-circuited rotor used in feed grinding devices at the "Bukhoroparranda" JSC enterprise. Also, the amount of active and reactive power consumed by feed mills in this enterprise during 2022 was analyzed, and an offer was made for compensation of reactive power. This article describes ways to achieve energy savings during the operation of an asynchronous electric motor used in feed choppers. The method of using an asynchronous electric motor for the purpose of energy saving of electricity is described. An analysis of the energy saving potential in feed grinding shows that significant savings in electrical energy can be obtained by increasing the efficiency of an asynchronous electric motor. This article provides information about the series and ratings of three-phase asynchronous motors with a squirrelcage rotor used in agricultural enterprises. The amount of active and reactive power consumed by an agricultural enterprise in 2022 was also analyzed, and a proposal was made to compensate for reactive power.

Keywords: Asynchronous motor, Active, Reactive and apparent Power, Power factor, Load, Electric power.

INTRODUCTION

In the conditions of rapid development of power engineering, which is considered one of the important sectors of the economy in our republic, energy and resource saving in asynchronous motors of feed grinding devices, production of high-quality products and effective exploitation of feed grinding devices in agricultural enterprises are considered one of the urgent problems of today. A number of decrees and decisions have been accepted by the President of our Republic in the development of this field. The tasks of reducing the energy and resource capacity of the economy, widely applying new energy-saving technologies to production, and increasing production productivity are indicated in Decree of the President of our Republic of Uzbekistan PD-2692 dated December 22, 2016 "On additional measures for the accelerated modernization of worn and obsolete equipment and reduction of production costs of industry enterprises", Decision of the President of the Republic of Uzbekistan DP-3238 dated August 23, 2017 "On measures to further introduce modern energy-efficient and energy-saving technologies", DP-4947 dated February 7, 2017 "On the strategy of actions for the further development of the Republic of Uzbekistan". In addition, this article serves to a certain extent in the implementation of tasks defined in the Law of the Republic of Uzbekistan "On rational use of energy" (No. 412-1), dated April 1997, Decision of the President of the Republic of Uzbekistan DP-3012 dated May 26, 2017 "On measures to further expand the use of energy sources" and other regulatory legal documents related to this activity. It is known that the agricultural sector in our Republic is improving and developing extensively. At present, the use of feed grinding devices used in agriculture and the need for it is increasing yearly. It is known that 70-80% of the electric energy consumption produced by power stations corresponds to electric motors [2].

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Therefore, at present, in the process of operation of asynchronous electric motors used in feed grinding devices, it is necessary to ensure their efficient operation, to improve the control of power consumption modes of energy devices using modern automated electrical systems.

Methods and materials

Nowadays, the main problems are to prevent short circuits occurring during the operation of asynchronous motors of feed grinding devices, to significantly reduce the costs for the repair of energy devices, in addition, to rational use of electricity, and special attention is paid to saving energy and resources. Therefore, energy-saving methods of operation of feed grinding devices are considered one of the urgent problems. At present, mainly asynchronous motors are used in fodder grinding devices in agricultural enterprises. Asynchronous motors are electromechanical devices that convert electrical energy into mechanical energy. It is widely used in agricultural enterprises due to its simplicity of structure, low price, and reliability during operation. Currently, asynchronous machines are mainly used as three-phase motors. Since the asynchronous motor has a simple structure, is easy to use, and has good energy and mechanical characteristics, more than 70 percent of the electric motors used in agricultural enterprises are asynchronous motors [1-15]. At present, feed grinding devices are being used in the “Bukhoraparranda” JSC. This enterprise has the following types of fodder grinding devices: KDU-2;0-1 type fodder grinding devices mainly use 2SE132M-4A, FDR100LC/4Q, 4A100L6U3, 4A100S4U3, 4A112MA6U3, 4AIRM06U3, 4AIRM11V6U3 and other three-phase short-circuited rotor asynchronous motors. Their capacity is 2.2 - 37 kW, and the voltage is 220/380 V. Three-phase asynchronous motors are the main consumers of reactive power in agricultural enterprises [15-18]. Experimental studies were conducted on asynchronous motors with voltage U=220/380 V and power P=2.2 kW to 37 kW, used in “Bukhoraparranda” JSC enterprise. In the course of experimental studies of asynchronous motors of feed grinding devices, we found out that it is possible to achieve energy savings by determining reactive power consumption and its compensation [12-20]. The oscillograms were received on a “Peak Tech-1240” type oscilloscope manufactured in Germany (Figure 1). shows the oscillogram of the phase voltage of the asynchronous motor of the feed grinding device in the mode of operation [12].

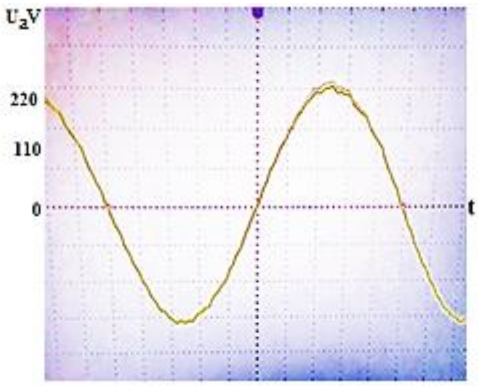


Figure 1: Oscillogram of the phase voltage of the asynchronous motor of the feed grinding device in the idling mode

The oscillogram shows that in this mode the change of phase voltage is sinusoidal. Therefore, it can be seen that the asynchronous motor consumes energy according to the norm. The oscillogram of the phase voltage of the asynchronous motor of the feed grinding device in the load mode is shown in Figure. 3. It can be seen from the oscillogram that the shape of the phase voltage on the graph is distorted compared to the shape of a sinusoid, because higher harmonics appear. So, if the sinusoid is disturbed, the reactive power consumption exceeds the norm, and the energy consumption in the asynchronous motor is not within the norm [5-16]. As a consequence, a lot of electricity is wasted. The oscillogram of the phase voltage of the asynchronous motor of the feed grinding device operating in the load mode in the case of reactive power compensation is shown in (Figure. 2), that is, the phase voltage oscillogram of the asynchronous motor operating in the load mode in the case of reactive power compensation.

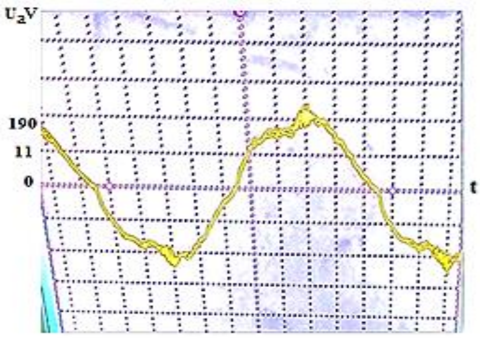


Figure 2. Oscillogram of the phase voltage of the asynchronous motor of the feed grinding device operating in the load mode without reactive power compensation

The dynamics of reactive power change is represented by the reactive power coefficient.

$$tg\varphi = \frac{Q}{P} \quad (1)$$

where;

$Q = U \cdot I \cdot sin\varphi$ - reactive power;

$P = U \cdot I \cdot cos\varphi$ - active power;

$\varphi -$ the angle between the voltage and current vectors.

In the complete description of the production modes of electricity consumers, the power factor $tg\varphi$ is widely used:

$$cos\varphi = \frac{P}{U \cdot I} \quad (2)$$

where;

$S = U \cdot I-$ full power. Power factor is a coefficient describing how much of the full power is used for useful work. If the power factor of the consumer decreases, the total power in the network increases, i.e. [16]:

$$S_T = \frac{P_P}{cos\varphi} \quad (3)$$

where; P_{p} - in conditions of active power of the consumer U and in unchanged values of indicators

$$I_P = \frac{P_p}{\sqrt{3} \cdot U \cdot cos\varphi} \quad (4)$$

the value of the reactive current increases, which leads to an increase in operating costs, that is, an increase in the loss of electrical energy in the network:

$$\Delta P = 3 \cdot R \cdot I_P^2 = \frac{R \cdot P_P^2}{U^2 \cdot cos^2\varphi} \quad (5)$$

where;

R-active resistance of one phase of a three-phase device.

The balance of active powers of the enterprise is expressed by the following expression

$$\sum P = P_{yu} + \Delta P: cos\varphi_i = \frac{1}{\sqrt{(1+tg\varphi_i^2)}}: \quad (6)$$

Determining the power factor of an asynchronous motor.

The power factor of an asynchronous motor is determined by the following expression [15]:

$$\cos\varphi = P/S = P/\sqrt{P^2+Q^2} \qquad (7)$$

$P = M\cdot\omega + 3\cdot I_1^2\cdot R_1$ - active power; where the angular speed is equal to

$$\omega = 2\cdot\pi\cdot f = 2\cdot\pi\cdot n\cdot p/60 = \pi\cdot n\cdot p/30$$

$$S = \sqrt{P^2+Q^2} \text{ - full power.} \qquad (8)$$

$$Q = 3\cdot I_\mu^2\cdot x_\mu + 3\cdot I_1^2\cdot x_1 + 3\cdot I_2^2\cdot x_2 \text{ - reactive power;}$$

Reactive power balance of the enterprise (before compensation) $\Sigma Q = Q_{юк} + \Delta Q$; $tg\varphi_{ai} = Q_i/P_i$;

$$\Delta W_i = \frac{P_i}{100}\cdot T_i$$

$$P = M\cdot\omega + 3\cdot I_1^2\cdot R_1;\ \omega = 2\cdot\pi\cdot f = 2\cdot\pi\cdot n\cdot p/60 = \pi\cdot n\cdot p/30 \quad (9)$$

In order to reach $\cos\varphi$ = 1.0 usually it is necessary to connect the battery of additional capacitors. Calculation of the capacity of the capacitors required for reactive power compensation is carried out by the following formula:

$$C = \frac{P}{\omega\cdot U^2}\cdot(tg\varphi_1 - tg\varphi_2), \quad (10)$$

where;

$P = I_a\cdot U$ – active power of the electric consumer;

$\omega = 2\cdot\pi\cdot f$ – angular frequency;

U – network voltage;

φ_1, φ_2 – angles between the current vector $\dot{I}$ and the network voltage U before and after reactive power compensation. Reactive power balance of the enterprise (after compensation)

$$\Sigma Q = Q_{юк} + \Delta Q - Q_{к.к.}; \quad v_{i.нор} = \frac{1}{\cos\varphi_{i.нор}^2}; \quad \cos\varphi_{i.нор} = \frac{1}{\sqrt{(1+tg\varphi_{i.нор}^2)}}; \quad n_э\cdot v_{i.нор}; \ \Delta W_{i.нор} = v_{i.нор}\cdot\Delta W_i;$$

$$\Delta W_{ЭЭi} = (\Delta W_{i.нор} - \Delta W_i); \quad (11)$$

Power of capacitor batteries are determined with the following formula

$$Q = P\cdot(tg\varphi_1 - tg\varphi_2).$$

$$\text{Sum} = \Delta W_{ЭЭi}\cdot n_э\cdot v_{i.нор} \quad (12)$$

METHODS AND MATERIALS

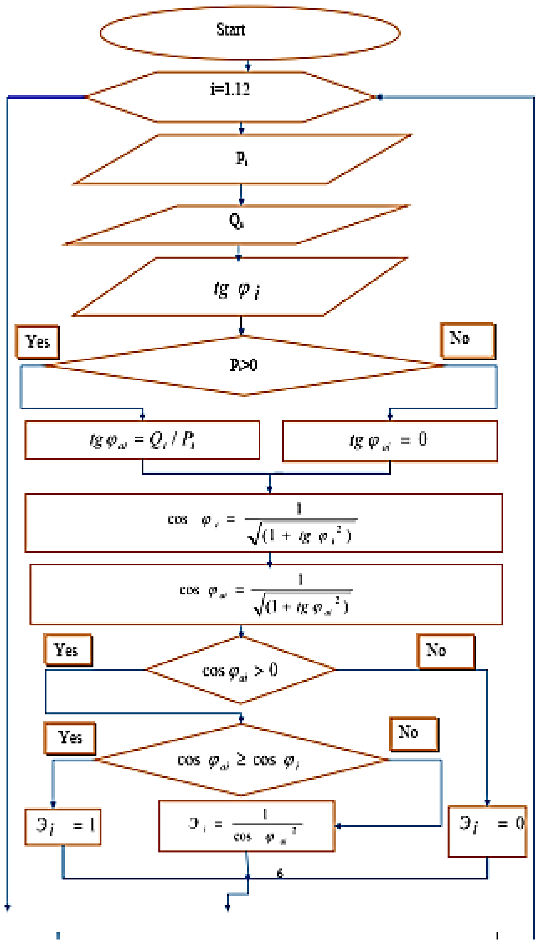
"Nowadays, the main challenges, goals the values of active and reactive power consumed in 2022 in feed grinding devices of JSC "Bukhoroparranda" are presented in Table 1 below.

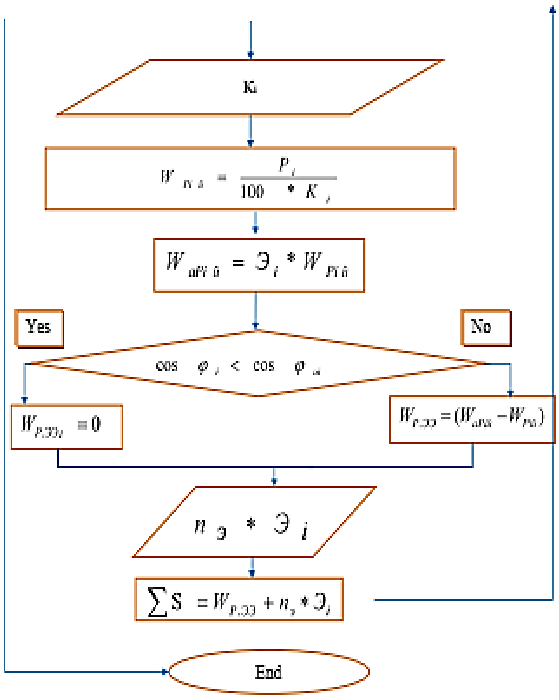
Table 1.

Months	W_a-kW*sec	W_p-kVAr*sec	Cost of 1-kW*sec energy
January	97522	37641	357
February	47155	31641	450
March	65083	36912	391
April	26629	56370	467
May	22982	41761	489

June	32826	47121	489
July	58952	35521	490
August	62111	29601	374
September	37393	11281	450
October	44449	10881	450
November	32420	10913	423
December	61213	10641	391
Total	**588735**	**360284**	

These tables basically shows that reactive power consumption has increased in recent years.





Algorithm for determining energy saving reserves by compensation of reactive power

This situation is negative, because it leads to an increase in power loss in asynchronous motors, and as a result, their useful efficiency decreases. Thus, as a result, a part of the electricity consumed by the enterprise leads to inefficient waste [11-19]. Therefore, it is necessary to compensate the reactive power. For this purpose, a panel with separate condensers is installed next to the cabinet at the enter of this workshop. Condensers are placed in this cabinet. We calculate and install the capacitors corresponding to the total power of the asynchronous motors used in this workshop using the following tables 2 and 3.

W_a - active energy (kW*h)

$tg\varphi$ - normative value of $tg\varphi$

$atg\varphi$ - actual value of $tg\varphi$

$cos\varphi_{\text{нор}}$ - normative $cos\varphi$

$acos\varphi$ -actual $cos\varphi$

$v_{i\text{нор}}$- normative power factor

$T_{i.\text{нор}}$- normative technological factor

W_p - reactive energy (kVAr*h)

$\Delta W_{iй\ \text{нор}}$- normative technological loss (kW*h)

$\Delta W_{i.a}$ - actual technological loss (kW*h)

$\Delta W_{ээ}$ - electricity (kW*h)

$n_э$ – monthly electricity price (variable)

Table of comparison by recalculation of reactive power consumption of asynchronous motors of feed grinding devices at the enterprise. As of 2022													
Table 3. Table of comparison by recalculation of reactive power consumption of asynchronous motors of feed grinding devices at the enterprise. As of 2022													
№	**Months**	**Name of enterprise**	**Actual consumption**		**normative value of tgφ**	**actual value of tgφ**	**according to the formula of normative cosφ**	**according to the formula of actual cosφ**	**Power factor waste 1/acosφ^2**	**normative technological loss kW*h**	**actual technological loss in kW*h**	**Repeated calculation**	
			Active ergy kW	**eactive ener kVAr*h**								**kW*h**	**Sum**
1.	January	Bukhoroparranda JSC	97522	37641	0.25	0.39	0.97	0.933	1.15	25 356	29 133	3 777	1 348 532.04
2.	February	Bukhoroparranda JSC	47155	31641	0.25	0.67	0.97	0.830	1.45	8 016	11 626	3 609	1 624 179.73
3.	March	Bukhoroparranda JSC	65083	36912	0.25	0.57	0.97	0.870	1.32	11 064	14 623	3 559	1 391 532.23
4.	April	Bukhoroparranda JSC	26629	56370	0.25	2,12	0.97	0.427	5,48	4 261	23 353	19 092	8 916 164.56
5.	May	Bukhoroparranda JSC	22982	41761	0.25	1.82	0.97	0.482	4,30	3 677	15 819	12 142	5 937 215.34
6.	June	Bukhoroparranda JSC	32826	47121	0.25	1.44	0.97	0.572	3,06	5 252	16 075	10 823	5 292 244.17
7.	July	Bukhoroparranda JSC	58952	35521	0.25	0.60	0.97	0.857	1.36	9 432	12 857	3 424	1 677 984.27
8.	August	Bukhoroparranda JSC	62111	29601	0.25	0.48	0.97	0.903	1.23	9 938	12 195	2 257	844 181.50
9.	September	Bukhoroparranda JSC	37393	11281	0.25	0.30	0.97	0.957	1.09	5 983	6 527	545	245 040.23
10.	October	Bukhoroparranda JSC	44449	10881	0.25	0.24	0.97	0.971	1.00	7 112	7 112	0	0.00
11.	November	Bukhoroparranda JSC	32420	10913	0.25	0.34	0.97	0.948	1.11	7 363	8 197	834	352 884.68
12.	December	Bukhoroparranda JSC	61213	10641	0.25	0.17	0.97	0.985	1.00	13 901	13 901	0	0.00
		Total:	**588735**	**360284**								**60 063**	**27 629 958.75**

3 Results and discussion

In the operation process of asynchronous motors used in feed grinding devices of "Bukhoroparranda" JSC, energy saving was achieved by compensating the reactive power through static capacitors [20].

Figure 3: General view of the installation of reactive power compensation capacitors in a feed grinding shop

As can be seen in the next oscillogram (Figures 4), in the course of experimental studies of asynchronous motors of the same voltage and the same power, during the operation of asynchronous motors in load mode, in the process of obtaining an oscillogram by connecting a static capacitor to asynchronous motors, it can be seen that in the graph, due to the compensation of higher harmonics, the shape of the phase voltage is close to a sinusoid [8-17].

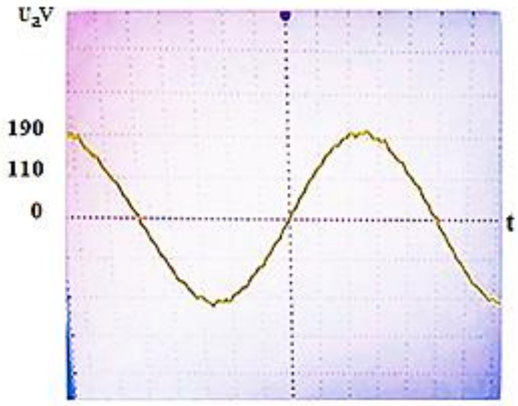


Figure 4: The oscillogram of the asynchronous motor phase voltage of the feed grinding device operating in load mode with reactive power compensation

The oscillogram of the phase voltage of the asynchronous motor of the feed grinding device operating in load mode with reactive power compensated is shown in (Figures 4). In this case, since the higher harmonics are compensated, the shape of the phase voltage is close to a sinusoid.

4 CONCLUSION

In summary, we can say that the purpose of using controlled static capacitors during the operation of asynchronous motors of the feed grinding devices used in agricultural enterprises is not only to compensate the reactive power, but also to maintain the set value of the voltage transmitted from the network without changing during maximum and minimum loads. As a result, in the case of "Bukhoroparranda" JSC enterprise, in the feed grinding shop, reactive power was covered by static capacitors and energy saving was achieved, and efficiency made **27,629,958.75 UZS (60,063 kW*h)** in one year.

REFERENCES

References

1. Baratov, R., Pirmatov N., Panoev A., .Ruziyev S., Mustafoqulov, A. Achievement of electric energy savings through controlling frequency convertor in the operation process of asynchronous motors in textile enterprises. IOP Conference Series:Materials Science and Engineeringthis link is disabled, 2021, 1030(1), 012161
2. Pirmatov, N., Panoev A. Frequency control of asynchronous motors of looms of textile enterprises. E3S Web of Conferences, 2020, 216, 01120
3. Toirov O., Alimkhodjaev K., Pirmatov N., Kholbutaeva A. Mathematical model to take into account the influence of saturation of the magnetic circuit on the starting characteristics of a synchronous motor. E3S Web of Conferences, 2020, 216, 01119
4. Pirmatov N.B., Panoev A.T., Samatova G., and Berdiyorov O'.N.. Determination of methods of achieving the energy savings through mathematical modeling of static and dynamic modes of electromagnetic energy conversion in asynchronous motors used in feed crushers. E3S Web of Conferences 383, 04046 (2023) TT21C-2023.
5. Pirmatov Nurali Berdiyorovich, Panoev Abdullo Tilloevch -Optimized Control of the Speed of Asynchronous Motor of the Feed Grinding Devices Used in Agricultural Enterprises. ISSN: 2350-0328 International Journal of Advanced Research in Science, Engineering and Technology Vol. 10, Issue 5, May 2023. Copyright to IJARSET www.ijarset.com 20649-20654.
6. Pirmatov Nurali Berdiyorovich , Panoev Abdullo Tilloevich-Energy Saving in Asynchronous Motors Used for Devices of Fodder Shredders. ISSN: 2350-0328 International Journal of

AdvancedResearch in Science, Engineering and Technology Vol. 10, Issue 10, October 2023. Copyright to IJARSET www.ijarset.com 21114-21117.

7. A.Panoev.,M.Bozorov-Compensation of Reactive Power in Asynchronous Motors of Agricultural Enterprises. In volume 16, of Eurasian Journal of Engineering and Technology (EJET) March, 2023. P.8-14.ISSN (E): 2795-7640 JIF: 8.115 .Genius Journals Publishing Group, Brussels, Belgium.|Google Scholar|
8. Abdullo Panoev., Makhsum Bozorov-Achieving energy saving by covering the reactive power in the operation of asynchronous motors used in agricultural enterprises. European Journal of Agricultural and Rural Education (EJARE) Available Online at: https://www.scholarzest.com Volume 4. No. Issue 3 of the, March 2023. P. 14-22. ISSN:2660-5643. IMPACT FACTOR: 7.354 |Google Scholar|.
9. Panoyev A.T., Bozorov M.B., Ahmadov E.K.-Measures to save electrical energy in static and dynamic modes of asynchronous motors used in agriculture. Vol. 1 No. 9 (2023): P.142-147. Prospects of development of science and education .
10. Abdullo Panoev, Makhsum Bozorov. Indicators of Electricity Consumption in Asynchronous Motors Used in the Agricultural Industry. Volume 19| June2023. P. 1-8. ISSN: 2795-7640.Eurasian Journal of Engineering and Technology.
11. A.T. Panoev., M.B. Bozorov. Achievement Of Energy Saving When Operating Equipment for Livestock Feed. Vol. 28 (2024) P. 1-7. ISSN: 2795-7640: EJET | Eurasian Journal of Engineering and Technology.
12. Pirmatov Nurali., Panoev Abdullo. Control of static and dynamic modes of asynchronous motor of fodder grinding devices. Scientific and Technical Journal Namangan Institute of Enginering and Technology Volume 8 Issue 2. 2023. ISSN 2181-8600.UDC 621.323.p 252-258.
13. Pirmatov N.B., Panoev A.T.. Energy saving on asynchronous motors applicable on feed grinders. Proceedings of the International University Scientific Forum "Practice Oriented Science: UAE - RUSSIA - INDIA". (August 25, 2023. UAE) ISBN 978-5-905695-87-5. DOI 10.34660/INF.2023.29.32.062 P.158-160.
14. Panoev Abdullo Tilloevich.
通过饲料研磨设备感应电机的最佳速度控制实现节能.Achievement of energy savings through optimal speed control of an induction motor for feed grinding devices.
上合组织国家的科学研究：协同和一体化 国际会议 参与者的英文报告 International Conference "Scientific research of the SCO countries: synergy and integration" Part 1 2023 年 10 月 14 日。中国北京 October 14, 2023. Beijing, PRC. ISBN 978-5-905695-82-7. DOI 10.34660/INF.2023.39.13.430 UDC 621.323. 国际会议 140-142.
上合组织国家的科学研究：协同和一体化.
15. Pirmatov, N.B., Panoev, A.T. Energy Saving by Ensuring Steady Operation of Asynchronous Motor of Fodder Grinding Devices in Static and Dynamic Modes AIP Conference Proceedings, 2024, 2969(1), 060004