Indicators of Electricity Consumption in Asynchronous Motors Used in the Agricultural Industry

Abdullo Panoev
Doctor of Philosophy in Technical Sciences, Associate Professor. Head of the Department of "Electric Power Engineering and Electrical Engineering". National Research University "**Tashkent** Institute of Irrigation and Agricultural Mechanization Engineers" Bukhara Institute of Natural Resources Management.

Makhsum Bozorov
PhD, docent. Bukhara Engineering-Technologycal Institute.

ABSTRACT

In this articleways to achieve energy savings during the operation of an asynchronous electric motor are described. The method of using an asynchronous electric motor for the purpose of energy saving of electricity is described. Analysis of the energy saving potential that significant savings in electrical energy can be obtained by improving the efficiency of the asynchronous motor.

Keywords: Induction motor power factor, active power, reactive power, apparent power, power factor load, power dependency to two polar generators

Introduction. As you know, the agrarian sector in our republic is improving and developing more and more. Three-phase asynchronous motors are the main consumers of electricity used in agricultural enterprises. 70-80% of the generated electricity is used in electric motors [1,2]. However, the main part of the main reactive power consumption in electric motors is in asynchronous motors. With this in mind, compensation and increase in the reactive value that exceeds the norm in asynchronous motors [3,4]. Therefore, during the operation of the feed grinding device, a number of measures should be taken to start the asynchronous motor of the device, as well as to stabilize the supply voltage [4,5]. At present, a large amount of reactive power is consumed in the process of using an induction motor, which is used on the example of one of the agricultural enterprises "Research Institute of Agrotechnologies of Cotton Growing, Seed Growing, Bukhara". scientific and experimental station (PGUPAPTI Bukhara ITS)". At the same time, to increase the power factor of an asynchronous motor and reduce power losses in electrical equipment during operation of an asynchronous motor [6,7].

Currently, modern imported equipment and technologies are being introduced into the Republic of Uzbekistan, which must be provided with electricity in accordance with the requirements of European standards. Otherwise, this technique may not provide the expected quality and performance. Modern technological installations have an active feedback effect on the electrical network, and at the same time impose stringent requirements on the quality of electricity and the reliability of solar power plants[8,9]. These circumstances require the reconstruction of enterprises, taking into account modern requirements, in particular, in terms of quality and efficiency in the use of electricity, automation of consumption, accounting, etc. Power loss inasynchronous motorare made up of losses in the stator (43.6%) and rotor (12.7%) windings, as well as power losses in the steel of magnetic systemsasynchronous motor(43.7%). The total share of electrical and mechanical power losses inasynchronous motoraccount for 10.2% of active power consumption by motors[10,11].

Method. Total reactive power consumedasynchronous motor, consists of reactive powers due to the dissipation of stator (10.3%) and rotor (7.7%) windingsasynchronous motor, and reactive power of magnetization circuits (82%). Reactive power consumedasynchronous motor.In asynchronous motors, when the voltage changes, the currents in the stator and rotor windings and the magnetizing current of the motor change. Magnetizing losses increase with the square of the voltage. If the useful power given by the electric motor to the working body of an industrial installation is constant with a change in voltage, the losses in the stator and rotor vary inversely with the square of the voltage. Thus, the ratio of magnetization losses and electrical losses in the motor windings are different depending on the motor load: with a heavily loaded motor, the proportion of magnetization losses increases.In the total reactive power consumedasynchronous motor, a significant proportion is the reactive power of magnetization, proportional to the square of the mains voltage. Voltage reduction by 10% reactive power consumptionasynchronous motor decreases by 12-14%. When the engine is underloaded, switching from the “delta” to the “star” circuit is recommended rice -1. [12,13]

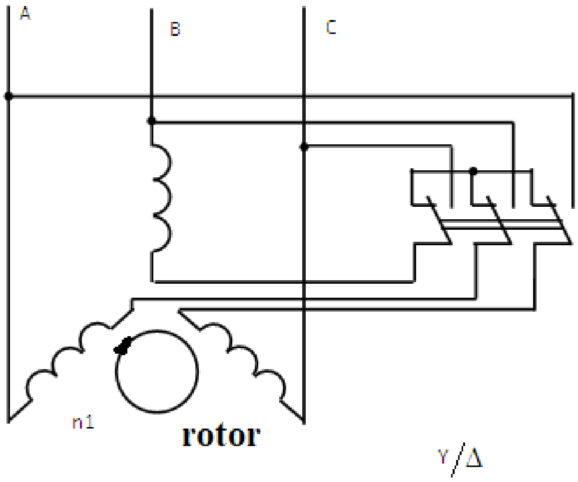

Fig.1. Connection diagram of the phases of the stator winding of an asynchronous motor

This reduces the consumption of not only active power, but also reactive power. Energy savings is [14,15]:

$$\Delta W_э = (\Delta P + k\Delta Q\ ) \cdot \Delta t;$$

(1)

Reducing power losses during the transition from the "triangle" to the "star" we have:

$$\Delta P_a = \frac{P}{\eta_\Delta} - \frac{P}{\eta_Y} = \frac{P}{\eta_\Delta} \cdot (\frac{\eta_Y - \eta_\Delta}{\eta_Y});\ \ kVt;$$

(2)

reactive power reduction:

$$\Delta Q = \frac{P}{\eta_\Delta} tg\varphi_\Delta - \frac{P}{\eta_Y} tg\varphi_Y;$$

(3)

And the total active power savings:

$$\Delta P = k \cdot \Delta Q + \Delta P,$$

(4)

where: k-factor that determines the loss of active power corresponding to 1 kvar of reactive power, kW/kvar.

An effective means of energy saving in asynchronous electric drives is to reduce the voltage supplied to the motor during its operation with small loads or in idle mode. In this case, there is a decrease in the consumed reactive power and, thereby, losses in the elements of the power supply system.electric drive,and when opdetermined load factors - and power losses in the engine. The reactive power Q consumed by the asynchronous motor when using P-figurative scheme substitution is determined by the formula:[16,17]

, (5)$Q = Q_{\text{ГП}} + Q_{\text{ПР}} = 3 \cdot U_1 \cdot I_\mu + 3 \cdot I_1^2 \cdot X_1 + 3 \cdot I_2'^2 \cdot X'_2 = 3 \cdot \frac{U_1^2}{\text{X}_\mu} + 3 \cdot\cdot I_2'^2 \cdot X_{\text{к.з}} = 3 \cdot \frac{U_1^2}{\text{X}_\mu} + \text{M} \cdot \omega_0 \cdot S \cdot \frac{X_{\text{к.з}}}{R'_2}$ (5)

where Qgp, Qpr - reactive power, respectively, of the magnetic main field (GP) and magnetic stray fields (PR) of the stator and rotor windings; U1 - voltage applied to the motor; Iμ, Xμ - respectivelycurrent and reactance of the magnetization circuit;I1- stator current; I2 - reduced rotor current; X1, X2,Xk.z- inductive resistances, respectively, of the stator winding, reduced rotor winding and short circuit, Xk.z = X1+X2 M, ω0, S - respectively, the moment, idle speed and slip of the asynchronous motor. It follows from the expression that by reducing the voltage supplied to the motor, it is possible to influence the level of reactive power consumed by the motor and, thereby, the value of cosφ. This situation is illustrated by the dependences of the magnetization current Iμ and the reduced rotor current I2 on the motor supply voltage U1* = U1/U1nom at different load moments Ms, shown in Fig.1.

It can be seen from Fig. 2 that a decrease in voltage leads to a decrease in the magnetizing current and, accordingly, in that part of the consumed reactive power that goes to create the main magnetic flux of the motor.

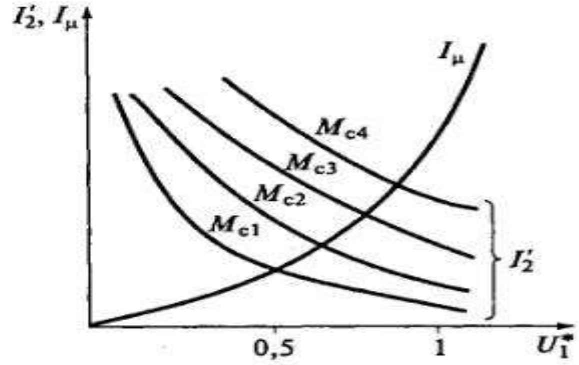

***Fig.2.* Dependences of the magnetizing current and the reduced current of the rotor on the voltage on the stator**

At the same time, at a constant moment, the loads increasecurrents incircuits of the stator and rotor of the motor, which causes an increase in consumptionreactive power used to create stray fields of the stator and rotor windings. Thus, voltage reduction can be carried out only at low motor loads or when it is idling, when the voltage reduction, which leads to a decrease in the motor magnetic flux, will not cause an increase in currents in the motor circuits[18,19]. For practical calculations, it is convenient to write the expression in the following form, which allows taking into account the degree of load kn of the engine[1]:

$$Q = Q_0 + k_{\text{н}}^2 \cdot \Delta Q,$$

(6)

where Qo - reactive power at idle speed of the engine; ΔQnom - increase in reactive power during the transition
engine from idle to nominal.

The increase in reactive power is determined by the formula

$$\Delta Q_{\text{ном}} = (Q_{\text{ном}} - Q_0),$$

(7)

where Qnom - reactive power in nominal mode.

Reactive power in nominal mode is determined by the formula

$$Q_{\text{ном}} = 3 \cdot U_{\text{ф}} \cdot I_{1\text{ном}} \cdot \sin\varphi_{\text{ном}} = P_{\text{ном}} \cdot \frac{\tan\varphi_{\text{ном}}}{\eta_{\text{ном}}}. \qquad (8)$$

In practice, two ways to reduce the voltage have been applied: by switching the stator winding of the "triangle" circuit to the "star" circuit and by using thyristor voltage regulators. Consider the first of these methods. This method of voltage reduction is possible when the nominal phase voltage of the motor stator winding is equal to the line voltage of the network. At motor loads close to the nominal level, the stator windings are connected in a delta (Δ) and the motor operates at rated voltage with full magnetic flux. When the load decreases, the motor windings switch to the "star" (Y) circuit, a reduced voltage is supplied to the windings in √3 = 1.73times the voltage, thereby reducing the magnetizing current, reactive power and total losses in the motor and systempower supply. It is important to note that, in this case, the power losses in the engine, depending on its load factor, can bothdecrease as well as increase. The dependence of the reactive power of an induction motor on the voltage applied to the stator can be expressed by the formula[2].

$$Q \approx k_U^2 \cdot Q_0 + k_{\text{н}}^2 \cdot \frac{\Delta Q_{\text{ном}}}{k_U^2},$$

(9)

where ku is the voltage reduction factor equal to one when the stator windings are connected in a delta circuit and 1/√3 when the stator windings are connected in a star circuit[20,21].

The dependence of active power losses of an induction motor on the voltage applied to the stator can be expressed by a similar formula.

$$\Delta P \approx k_U^2 \cdot \Delta P_0 \ + k_{\text{н}}^2 \cdot \frac{\Delta P_{\text{ном}}}{k_U^2},$$

(10)

where ΔP0 is the power loss in the engine during idling, further taken to be equal to constant losses K.

Substituting in formulas (2) and (3) the values of ku for both circuits, it is possible to determine the reduction in reactive power ΔQΔ-Y when switching windings:

$$\Delta Q_{\Delta-\text{Y}} = Q_{\Delta} - \Delta Q_{\text{Y}} = 2 \cdot \frac{Q_0}{3} - 2 \cdot k_{\text{н}}^2 \cdot \Delta Q \qquad (11)$$

as well as reducing power losses Δ(ΔPΔ-Y) with this switching:

(9)$\Delta P_{\Delta-\text{Y}} = \Delta P_{\Delta} - \Delta P_{\text{Y}} = 2 \cdot \frac{\Delta P_0}{3} - 2 \cdot k_{\text{н}}^2 \cdot \Delta P_{\text{ном}}.$ (12)

An analysis of the ratio for the most probable values ΔQo = (0.60...0.75) ΔQ shows that with a load factor kn < 0.7, the reactive power in the "star" circuit is always less than in the "triangle" circuit. Analysis of formula (5) with the most probable ratio ΔP0 ≈ (0.30...0.35) ΔPnom shows that the reduction of power losses in the engine during the transition to the "star" scheme will take place starting from the values of the engine load factor kn < 0 ,4.

The formula for calculating the maximum possible relative load moment M*s at ku=1/√3, which is typical when switching the stator windings from the "triangle" to the "star" circuit, at which the rotor current, power losses and heating do not exceed the nominal level:

$$\text{M}_{\text{C}}^{*} = \frac{\left(\mathbf{2}\cdot\boldsymbol{\lambda}_{\text{М}}\cdot\left(\boldsymbol{\lambda}_{\text{М}}+\sqrt{\boldsymbol{\lambda}_{\text{М}}^{\mathbf{2}}-\mathbf{1}}\right)-\mathbf{3}\right)^{\frac{\mathbf{1}}{\mathbf{2}}}}{\sqrt{\mathbf{3}}\cdot\left(\boldsymbol{\lambda}_{\text{М}}+\sqrt{\boldsymbol{\lambda}_{\text{М}}^{\mathbf{2}}-\mathbf{1}}\right)}.$$

(13)

In an asynchronous motor, when the stator windings are included in the "star" circuit, the motor, due to heating conditions, cannot carry a load of more than 60%. Consider an example of evaluating the economic efficiency of the considered method of energy saving.

Results. Determine the feasibility of the energy saving method in the electric drive by switching the motor windings4A100S4U3,operating with a load factor kn = 0.3, from the "triangle-nick" scheme to the "star" scheme. Rated motor data: Pnom= 30 kW; Unom= 220/380 V; Snom= 0.02; I1nom = 41.2 A; cosφnom = 0.85; sinφnom = 0.49; ηnom= 90%; λm \u003d Mk / Mnom \u003d 2.2; p = 3; f1nom = 50 Hz.

- the operating time of the engine with the specified load factor per year is Tr = 1500 h;
- the considered method of energy saving is implemented by creating a relay-contactor circuit for switching windings using four contactors.

- coefficient of depreciation deductions ka is taken in the amount of 10%;

- the tariff for electricity SE is 295 UZS / kWh (Uzbekistan, 2023).

We determine the ideal idle speed and the nominal angular velocity and moment:

$$;\omega_0 = \frac{2\cdot\pi\cdot f_1}{p} = 2\cdot 3{,}14\cdot\frac{50}{3} = 104{,}7\ rad/s \qquad (14)$$

$$;\omega_{\text{ном}} = \omega_0\cdot(1 - S_{\text{ном}}) = 104{,}7\cdot(1-0{,}02) = 103\ rad/s \qquad (15)$$

$$\text{М}_{\text{ном}} = \frac{P_{\text{ном}}}{\omega_{\text{ном}}} = \frac{30000}{103} = 291{,}3\ \ Nm. \qquad (16)$$

Determine the nominal reduced current of the rotor:

$$I'_{2\text{ном}} \approx I_{1\text{ном}}\cdot\cos\varphi_{\text{ном}} = 41{,}2\cdot 0{,}85 = 48{,}5\ \ \text{A}. \qquad (17)$$

We find the magnetizing current of the motor: Using the expression for the power loss in the rotor V2=I'22R'2=Mω0S, written for the nominal mode, we find the reduced active resistance of the rotor:[source, page]

$$R'_2 = \frac{(M_{\text{ном}}\cdot\omega_0\cdot S_{\text{ном}})}{3\cdot I'^2_{2\text{ном}}} = \frac{291{,}3\ \ \cdot 104{,}7\cdot 0{,}02}{3\cdot 48{,}5^2} = \frac{609{,}9822}{7056{,}75} = 0{,}09\ \text{Om}$$

We calculate the reactive power in the nominal mode:

$$Q_{\text{ном}} = 3\cdot U_{\varphi}\cdot I_{1\text{ном}}\cdot\sin\varphi_{\text{ном}} = 3\cdot 220\cdot 41{,}2\cdot 0{,}49 = 13324{,}08\ \ var.$$

We calculate the reactive power of idling:

$$Q_0 = m\cdot P_{\text{ном}}/\eta_{\text{ном}} = 0{,}31\cdot\frac{30000}{0{,}90} = 10333\ var, \qquad (18)$$

where m = 2.2-2.1 cosφnom = 2.2 - 2.1 0.85 = 0.415.

From the expression for the rated reactive power

$$Q_{\text{ном}} = 3\cdot U_{\varphi}\cdot I_{\mu} + \text{М}_{\text{ном}}\cdot\omega_0\cdot S_{\text{ном}}\cdot\frac{\text{Х}_{\text{к.з}}}{R'_2} = Q_0 + \Delta Q_{\text{ном}} \qquad (19)$$

find Hk.z:

$$\text{Х}_{\text{к.з}} = R'_2\cdot\frac{(Q_{\text{ном}} - Q_0)}{\text{М}_{\text{ном}}\cdot\omega_0\cdot S_{\text{ном}}} = 0{,}09\cdot\frac{(13324{,}08 - 10333)}{(291{,}3\cdot 104{,}7\cdot 0{,}02)} = 0{,}09\cdot\frac{2991{,}08}{609{,}9822} = 0{,}44\ Om.$$

We determine the active resistance of the stator circuit usingformula for critical momentasynchronous motor:

$$\text{М}_{\text{к}} = 3\cdot U^2_{\Phi}/2\cdot\omega_0\cdot(R_1 + \sqrt{R_1^2 + \text{Х}^2_{\text{к.з}}}).$$

Expressing R1 from it as the desired value, we find: [5]

$$R_1 = ((\frac{3\cdot U^2_{\Phi}}{2\cdot\omega_0\cdot\text{М}_{\text{к}}})^2 - \text{Х}^2_{\text{к.з}}))/((2\cdot(3\cdot\frac{U^2_{\Phi}}{2\cdot\omega_0\ \cdot\text{М}_{\text{к}}}))$$

$$== \frac{((\frac{3\cdot 220^2}{2\cdot 104{,}7\cdot 2{,}2\cdot 213{,}6})^2 - 0{,}44^2)}{\left(2\cdot\left(\frac{3\cdot 220^2}{2\cdot 104{,}7\cdot 2{,}2\cdot 213{,}6}\right)\right)}$$

$$= \frac{((\frac{145200}{98401{,}248})^2 - 0{,}1936)}{\left(2\cdot\left(\frac{145200}{98401{,}248}\right)\right)} = \frac{1{,}9968}{2{,}9512} = 0{,}68\ \text{О}m$$

Determine the total nominal losses:

$$\Delta P_{\text{ном}} = \frac{P_{\text{ном}}\cdot(1 - \eta_{\text{ном}})}{\eta_{\text{ном}}} = \frac{30000\cdot(1-0{,}82)}{0{,}82} = \frac{5400}{0{,}82} = 6585\ Vt$$

We find variable nominal losses:

$$V_{\text{ном}} = V_{1\text{ном}} + V_{2\text{ном}} = 3\cdot I^2_{1\text{ном}}\cdot R_1 + 3\cdot I'^2_{2\text{ном}}\cdot R'_2 = = 3\cdot 41{,}2^2\cdot 0{,}68 + 3\cdot 48{,}5^2\cdot 0{,}04 = 3462{,}7776 + 282{,}27 = 3745\ \ Vt.$$

Finding permanent power losses

$$\text{К} = \Delta P_{\text{ном}} - V_{\text{ном}} = 6585 - 3745 = 2840\ Vt.$$

We calculate by formula (8) the decrease in reactive power ΔQΔ-Y when switching the stator windings from the “triangle” circuit to the “star” circuit:

$$\Delta Q_{\Delta-\text{Y}} = \Delta Q_{\Delta} - \Delta Q_{\text{Y}} = 2\cdot\frac{\Delta Q_0}{3} - 2\cdot k^2_{\text{н}}\cdot\Delta Q_{\text{ном}} = 2\cdot\frac{8261}{3} - 2\cdot 0{,}3^2\cdot\ \cdot 13324{,}08 = 5507{,}2864 - 2398{,}3344 = 3109\ var.$$

Using formula (9), we calculate the reduction in active power Δ (ΔPΔ-Y) when switching the stator windings from the “triangle” circuit to the “star” circuit

$$\Delta(\Delta P_{\Delta-\mathrm{Y}}) = \Delta P_{\Delta} - \Delta P_{\mathrm{Y}} = 2\cdot\frac{\Delta P_0}{3} - 2\cdot k_{\text{н}}^2\cdot \Delta P_{\text{ном}} = 2\cdot\frac{2107}{3} - 2\cdot 0{,}3^2\cdot 6585 = 1404{,}7 - 1185{,}3 = 219\, Vt.$$

The total reduction in power losses will be

$$\Delta P_{\text{эк}} = k_{\text{п}}\cdot\Delta Q_{\Delta-\mathrm{Y}} + \Delta\cdot(\Delta P_{\Delta-\mathrm{Y}}) = 0{,}1\cdot 4490\ + 219 = 668\, Vt,$$

where kn is the coefficient of power loss reduction obtained from the reduction of reactive power Q, kW/kvar.

Payback time The current is determined by the formula

$$\mathrm{T}_{\text{ок}} = \text{Ц}_{\text{конт}}/(\mathrm{T}_{\mathrm{p}}\cdot \mathrm{C}_{\text{э}}\cdot \Delta\mathrm{P}_{\text{эк}} - \mathrm{p}_{\mathrm{a}}\text{Ц}_{\text{конт}}) = \frac{1{,}6\cdot 4\cdot 2022}{1500\cdot 295\cdot 0.668 - 0{,}1\cdot 4\cdot 2022} = \frac{12940{,}8}{295590 - 808{,}8} = \frac{12940{,}8}{294781{,}2} = \ 0{,}04\, y.$$

Discussion and conclusions:

Theoretical calculations and experimental data show that in the case of the enterprise "Research Institute of Agrotechnologies for Breeding, Seed Production of Cotton at the Bukhara Research and Experimental Station (NPGUAIT Bukhara ITS)", when an asynchronous motor is running, connecting the coils of an asynchronous motor, connecting electricity according to the triangle-star scheme reduces losses by a few percent, which saves electricity for an asynchronous motor.

Reference

1. N.N. Sadullaev., A.Kh. Shoboev., M.B. Bozorov., A.T. Panoev.Sistema monitoringa elektropotrebleniy predpriyatiya na osnoe koeffitsienta effektivnosti sistemy elektrosnabzheniya. Europaische Fachhochschule. Volume: 08 / 2016. P.40-43. URL:https://www.elibrary.ru/item.asp?id=27542999 e- ISSN: 2195-2183
2. N.N. Sadullaev., A.Kh. Shoboev., M.B. Bozorov., A.T. Panoev. Evaluation of the effectiveness of the system of electrical supply by the method of mnogokriterialnogo analysis. Europaische Fachhochschule. Volume: 08 / 2016. P.36-39. URL:https://www.elibrary.ru/item.asp?id=27542998 e- ISSN: 2195-2183
3. Садуллаев Н. Н., Бозоров М. Б., Нематов Ш. Н. КОНТРОЛЬ ЭФФЕКТИВНОСТИ ФУНКЦИОНИРОВАНИЯ ПРОМЫШЛЕННОЙ СЕТИ ПО ОБОБЩЕННОМУ ПОКАЗАТЕЛЮ ЭФФЕКТИВНОСТИ СИСТЕМЫ ЭЛЕКТРОСНАБЖЕНИЯ //3· 2018_. – 1992. – С. 57. URL:https://assets.uzsci.uz/edition/file/5e43dd733cce7.pdf#page=57
4. MB BOZOROV., II KHAFIZOV., JM ZOIROV., FR KAYIMOV., BS KHAMDAMOV., D.A. ORIPOV., SHARIPOV A.SH. Forecasting electricity consumption of industrial enterprises using excel program. JournalNX- A Multidisciplinary Peer Reviewed Journal. Volume: 07 ISSUE 2 / 2021. P.346-350. URL:https://media.neliti.com/media/publications/342773-forecasting-electricity-consumption-of-i-ab0342bf.pdf e- ISSN: 2581-4230
5. Kh. I. Hafizov., M.B. Bozorov.Razrabotka metoda kompleksnogo issledovaniya energoeffektivnosti sistemy elektrosnabzheniya promyshlennyx predpriyati. Sbornik statey Mejdunarodnogo nauchno-issledovatelskogo konkursa. Petrazavodsk, Russia (2021). P. 10-19. URL:http://is.nkzu.kz/publishings/%7BC1D6204A-6585-4F17-B6AD E67180342C1C%7D.pdf#page=12
6. M.B. Bozorov., I.I. Hafizov., A.T. Panoev., J.M. Zoirov., Sh.K. Ergashev., F.R. Kayimov., B.S. Khamdamov., D.A. Oripov., A.Sh. Sharipov. Razrabotka metoda otsenki effektivnosti sistemy elektrosnabzheniya promyshlennyx predpriyatiy. Sbornik nauchnykh statey po itogam mejdunarodnoy nauchnoy conference. Kazan (2021).P. 42-45.

URL:https://www.elibrary.ru/item.asp?id=44776698

7. Bozorov M. B. ISSLEDOVANIYA ENERGOEFFEKITNOSTI SISTEMY ELEKTROSNABJENIYA OB'EKTOV ENERGOSYSTEM NA OSNOVE OBOBshchENNYX POKAZATELEY EFFEKITNOSTI //Rossiyskaya nauka v sovremennom mire. - 2018. - S. 69-71. URL:https://www.elibrary.ru/item.asp?id=36354438
8. Sadullayev NN, Bozorov MB, Nematov Sh N. Research of Efficiency of Functioning of System of Electro Supply of the Enterprise by Method Multi-Criteria Analysis //Journal of Electrical & Electronic Systems. - 2018. - T. 7. – no. 2. - S. 18-20. URL:https://www.hilarispublisher.com/open-access/research-of-efficiency-of-functioning-of-system-of-electro-supply-of-the-enterprise-by-method-multicriteria-analysis-2332- 0796-1000257.pdf
9. Sadullaev N. N., Shoboev A. Kh., Bozorov M. B. ISSLEDOVANIE VLIYaNIYa REGULIROVANYa PARAMETROVELEKTROENERGII NA VYBOR OPTIMALNOY SCHEMY ELEKTROSNABJENIya //Sovremennye instrumentalnye sistemy, informatsionnye tehnologii i innovatsii. - 2014. - S. 28-32. URL:https://www.elibrary.ru/item.asp?id=22546679
10. Bozorov M. B. et al. USE OF RENEWABLE ENERGY SOURCES FOR LOW-POWER ENTERPRISES IN UZBEKISTAN //British View. – 2022. – T. 7. – №. 3. URL: https://britishview.co.uk/index.php/bv/article/view/120
11. Bakhshiloevich B. M. et al. Development of A Method for A Comprehensive Study of the Efficiency of the Power Supply System of Industrial Enterprises //Open Access Repository. – 2022. – T. 8. – №. 04. – C. 71-77. URL: https://oarepo.org/index.php/oa/article/view/553
12. Bakhshiloevich B. M., Rasulovich Q. F., Akmalovich O. D. Development of a combined method for forecasting electricity consumption of an industrial enterprise llc evrosnar //World Bulletin of Social Sciences. – 2022. – T. 8. – C. 57-64. URL: https://www.scholarexpress.net/index.php/wbss/article/view/715
13. Panoev, Abdullo, and Makhsum Bozorov. "Compensation of Reactive Power in Asynchronous Motors of Agricultural Enterprises." *Eurasian Journal of Engineering and Technology* 16 (2023): 8-14.
14. URL: https://www.geniusjournals.org/index.php/ejet/article/view/3568
15. Panoev, Abdullo, and Makhsum Bozorov. "ACHIEVING ENERGY SAVING BY COVERING THE REACTIVE POWER IN THE OPERATION OF ASYNCHRONOUS MOTORS USED IN AGRICULTURAL ENTERPRISES." (2023). URL: https://scholarzest.com/index.php/ejare/article/view/3378
16. Xafizov Islam, Bozorov Maxsum, & Ahmadov Elmurod. (2023). SANOAT KORXONALARI ELEKT ENERGIYADAN FOYDALANISH SAMARADORLIGINI BAHOLASH. *Innovations in Technology and Science Education*, *2*(9), 1918–1929. Retrieved from https://humoscience.com/index.php/itse/article/view/936
17. Хафизов Ислам, Бозоров Махсум, & Жабборов Азизбек. (2023). ИССЛЕДОВАНИЕ ПРИМЕНЕНИЯ СОЛНЕЧНЫХ ПАНЕЛЕЙ ДЛЯ ПИТАНИЯ КАТОДНОЙ СТАНЦИИ МАГИСТРАЛЬНОГО ТРУБОПРОВОДА ГАЗЛИ-КОГОН. *Innovations in Technology and Science Education*, *2*(9), 1907–1917. Retrieved from https://humoscience.com/index.php/itse/article/view/935

18. 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 //PROSPECTS OF DEVELOPMENT OF SCIENCE AND EDUCATION. – 2023. – Т. 1. – №. 9. – С. 142-147.
19. URL: https://humoscience.com/index.php/pdce/article/view/767
20. Xafizov Islam, Bozorov Maxsum, & Zaripov Shaxzod. (2023). SANOAT KORXONALARI TRANSFARMATORLARINING SAMARADORLIGINI BAHOLASH. *Innovations in Technology and Science Education*, *2*(9), 1930–1942. URL: https://humoscience.com/index.php/itse/article/view/937
21. Bozorov M. FORECASTING ELECTRICITY CONSUMPTION OF MERGANTEX ENTERPRISE //Modern Science and Research. – 2023. – Т. 2. – №. 5. – С. 605-612.
22. URL: https://inlibrary.uz/index.php/science-research/article/view/20323