ISSN: 2582-4686 SJIF 2021-3.261, 2022-2.889, 2023-5.384, 2024-6.875 ResearchBib IF: 9.948 / 2024

THE MULTIDISCIPLINARY JOURNAL OF SCIENCE AND TECHNOLOGY

VOLUME-5, ISSUE-1

ENERGY-SAVING TECHNICAL MEASURES IN ASYNCHRONOUS MOTORS USED IN FODDER GRINDING EQUIPMENT OF AGRICULTURAL ENTERPRISES

Abdullo Panoev
PhD, Associate Professor (docent) "Tashkent Institute of Irrigation and Agricultural Mechanization Engineers" National Research University Bukhara Institute of Natural Resources Management. Uzbekistan. panoev_abdullo@mail.ru
Makhsum Bozorov
PhD, Associate Professor (docent) Bukhara Institute of Engineering and Technology
Nodirbek Nurulloyev
Bukhara Institute of Engineering and Technology

Abstract: *This paper describes ways of achieving energy saving when operating an induction motor used in forage choppers. The method of using the asynchronous electric motor for the purpose of energy saving of electric power is presented. The analysis of the potential of energy saving in forage grinding shows that significant savings of electric energy can be obtained by increasing the efficiency of the induction motor.*

Key words: *Power factor of induction motor, active, reactive, total power, load, power factor*

As it is known, the agricultural sector in our republic is increasingly improving and developing. Three-phase induction motors are the main consumers of electricity used in agricultural enterprises. 70-80% of the generated electricity is used in electric motors [5]. Nevertheless, the main part of the main reactive power consumption in electric motors is induction motors. Considering this, compensating and increasing the reactive magnitude exceeding the norm in induction motors used in feed chopping devices is considered as one of the main tasks [2]. Therefore, when operating the feed chopping device, a number of measures should be taken to start the induction motor of the device, as well as to stabilize the supply voltage Fig.1 [3].

Fig.1. General view of the universal forage chopper

At present, a large amount of reactive power is consumed in the process of using induction motor of feed chopping devices, which is used as an example of one of the agricultural enterprises. In this case, to increase the power factor of the induction motor and reduce power losses in electrical equipment during the operation of the induction motor, which is mainly used in the feed chopping device [6].

Currently, modern imported equipment and technologies are being introduced in the Republic of Uzbekistan, which need to provide electricity according to the requirements of European standards. Otherwise, this technique cannot provide the expected quality and productivity. Modern technological installations have an active feedback effect on the electric network, and at the same time impose strict requirements to the quality of electricity and reliability of SES. These circumstances imply the reconstruction of plants taking into account modern requirements, in particular, on the quality and efficiency of electricity utilization, automation of consumption, metering, etc. Power losses in asynchronous electric motor consist of losses in stator (43,6%) and rotor (12,7%) windings, as well as power losses in steel of magnetic systems of asynchronous electric motor (43,7%). The total share of electrical and mechanical power losses in asynchronous electric motor is 10.2 % in the active power consumption of motors.

The total reactive power consumed by an induction motor is composed of reactive power due to dissipation of stator (10.3%) and rotor (7.7%) windings of the induction motor and reactive power of magnetizing circuits (82%). Reactive power consumed by the induction motor. In induction motors, when the voltage changes, the currents in the stator and rotor windings and the magnetizing current of the motor change. The magnetizing losses increase in proportion to the square of the voltage. If the useful power given by the electric motor to the working body of the industrial plant is constant when the voltage changes, the losses in the stator and rotor change inversely proportional to 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 specific weight of magnetization losses increases. In the total reactive power consumed by the induction motor, a significant share is the magnetizing reactive power, which is proportional to the square of the mains voltage. If the voltage is reduced by 10%, the reactive power consumption of an induction motor decreases by 12-14%. At underloaded mode of the motor it is recommended to switch from the scheme "delta" to "star" Fig. 2.

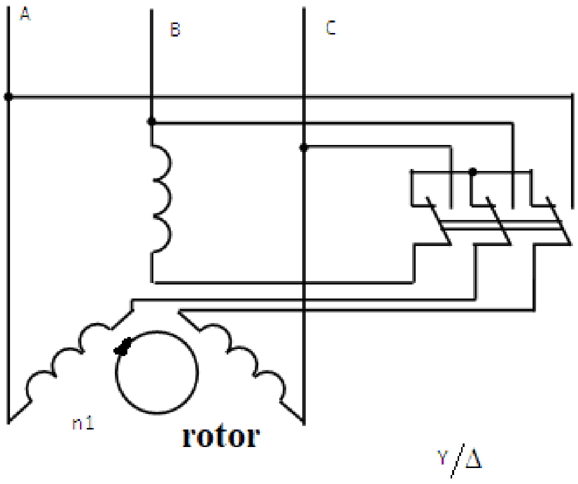

Fig.2. Schematic diagram of stator winding phases connection of induction motor of fodder grinding devices

Not only active power but also reactive power consumption is reduced. The saving of electric power is [2]

$$\Delta W_э = (\Delta P + k\Delta Q\ ) \cdot \Delta t; \qquad (1)$$

Reduction of power losses at transition from "delta" to "star" we have:

$$\Delta P_a = \frac{P}{\eta_\Delta} - \frac{P}{\eta_Y} = \frac{P}{\eta_\Delta} \cdot (\frac{\eta_Y - \eta_\Delta}{\eta_Y});\ \ квт; \qquad (2)$$

reduction of reactive power:

$$\Delta Q = \frac{P}{\eta_\Delta} tg\varphi_\Delta - \frac{P}{\eta_Y} tg\varphi_Y; \qquad (3)$$

And overall active power savings:

$$\Delta P = k \cdot \Delta Q + \Delta P, \qquad (4)$$

where: *k-coefficient* determining active power losses 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 when it operates with low loads or in the mode of operation This reduces the reactive power consumption and thus the losses in the elements of the electric supply system of the electric drive, and at certain load factors - and power losses in the motor. The reactive power Q consumed by the induction motor when using the U-shaped substitution scheme is determined by the formula [3]

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

where Q_{rn}, Q_{pr} - reactive powers of respectively magnetic main field (MF) and magnetic scattering fields (MSF) of stator and rotor windings; U_1 - voltage applied to the motor; $I_{(\mu)}$, X_μ - respectively current and reactive resistance of the magnetizing circuit; $I_{(1)}$ - stator current; ${}_{I(2)}$ - reduced rotor current; $X_{(1)}$, X_2, $X_{k.h.h}$ - inductive resistances of stator winding, reduced rotor winding and short-circuit winding respectively, $X_{k.s} = X_1 + X_2$ M, ω_0, S - respectively torque, idle speed and slip of induction 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 thus the value of cosφ. This position is illustrated by the dependences of magnetizing current I_μ and reduced rotor current I_2 on the motor supply voltage $U_1^* = U_{(1)}/U_{(1nom)}$ at different load torques M_s, shown in Fig. 1

Fig.3 shows that the reduction of voltage leads to a decrease in magnetizing current and, accordingly, the part of reactive power consumption that goes to create the main magnetic flux of the motor.

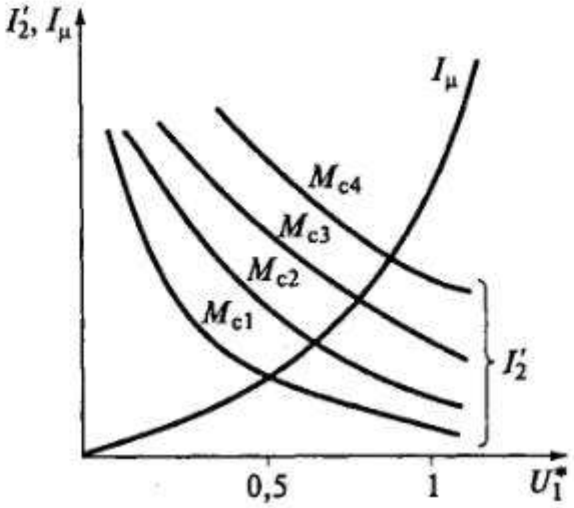

Fig.3. Dependences of magnetizing current and reduced rotor current on stator voltage of fodder grinding devices

At the same time, at the same load torque, the currents in the stator and rotor circuits of the motor increase, which causes an increase in the consumption of reactive power that goes to create dissipation fields of the stator and rotor windings

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

where Q_o - reactive power of the motor at idling; ΔQ_{nom} - increment of reactive power at the motor from idle to nominal

The increment of reactive power is determined by the formula

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

where Q_{nom} - reactive power in nominal mode.

Reactive power in nominal mode is determined by the formula

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

In practice, two methods of voltage reduction have been used: by switching the stator winding from delta to star circuit and by thyristor voltage regulators. Let us consider the first of these methods. This method of voltage reduction is possible when the nominal phase voltage of the motor stator winding and the line voltage of the network are equal. At motor loads close to the nominal level, the stator windings are included in the "delta" circuit (Δ) and the motor operates at nominal voltage with full magnetic flux. When the load is reduced, the motor windings are switched to a star circuit (Y) and the voltage is reduced by a factor of √3 = 1.73, which reduces the magnetizing current, reactive power and total losses in the motor and the power supply system. It is important to note that the power losses in the motor can either decrease or increase depending on its load factor. The dependence of induction motor reactive power on the voltage applied to the stator can be expressed by the formula [1].

$$Q \approx k_U^2 \cdot Q_0 + k_{\text{н}}^2 \cdot \frac{\Delta Q_{\text{ном}}}{k_U^2}, \qquad (6)$$

where k_u is the voltage reduction factor equal to one for delta connection of the stator windings and 1/√3 for star connection of the stator windings

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

$$\Delta P \approx k_U^2 \cdot \Delta P_0 \; + k_{\text{н}}^2 \cdot \frac{\Delta P_{\text{ном}}}{k_U^2}, \qquad (7)$$

where ΔP_0 - power losses in the engine at idling, taken hereafter equal to constant losses K.

By substituting the values of k_u for both circuits into formulas (2) and (3), the reactive power reduction $\Delta Q_{\Delta\text{-Y}}$ during winding switching can be determined:

$$\Delta Q_{\Delta-\text{Y}} = Q_\Delta - \Delta Q_{\text{Y}} = 2 \cdot \frac{Q_0}{3} - 2 \cdot k_{\text{н}}^2 \cdot \Delta Q_{\text{ном}} \qquad (8)$$

as well as the reduction of power losses $\Delta(\Delta P_{\Delta\text{-Y}})$during such switching:

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

Analysis of the ratio at the most probable values $\Delta Q_o = (0.60...0.75)\ \Delta Q_{nom}$ shows that at the load factor $k_n < 0.7$ reactive power in the scheme "star" is always less than in the scheme "delta". The analysis of formula (5) at the most probable ratio $\Delta P_{(0)} \approx (0,30...0,35)\ \Delta P_{nom}$ shows that the reduction of power losses in the motor at transition to the scheme "star" will take place starting from the values of the motor load factor $k_n < 0,4$.

Formula for calculating the maximum possible relative load torque M^*_s at $k_u=1/\sqrt{3}$, which is characteristic when switching the stator windings from delta to star, at which the rotor current, power losses and heating do not exceed the rated level:

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

Asynchronous motor's inclusion of stator windings in the scheme "star" motor under the conditions of heating can not carry a load of more than 60%. Let's consider an example of estimation of economic efficiency of the considered method of energy saving

Conclusions

Theoretical calculations and experimental data show that in the case of the enterprise in the operation of the induction motor of feed grinding devices, the connection of the coils of the induction motor, the connection of electricity in a delta-star scheme reduces losses by several percent, which saves electricity for the induction motor of widely used feed grinding devices.

LITERATURE

1. B., Bozorov M., et al. "Forecasting Electricity Consumption Of Industrial Enterprises Using Excel Program." *JournalNX*, vol. 7, no. 02, 2021, pp. 346-350

2. Panoev A., Bozorov M. Compensation of Reactive Power in Asynchronous Motors of Agricultural Enterprises //Eurasian Journal of Engineering and Technology. – 2023. – T. 16. – C. 8-14.

3. Bozorov Makhsum Bakhshiloevich, Khojimurodov Jasur Erkinovich, Khamdamov Bobir Sadullayevich, & Davronov Jahongir Rustamovich. (2022). DEVELOPMENT OF A METHOD FOR A COMPREHENSIVE STUDY OF THE EFFICIENCY OF THE POWER SUPPLY SYSTEM OF INDUSTRIAL ENTERPRISES. *Open Access Repository*, *8*(04), 71–77. https://doi.org/10.17605/OSF.IO/3JFZY

4. Bozorov Makhsum Bakhshiloevich, Qayimov Farrukh Rasulovich, & Oripov Doston Akmalovich. (2022). DEVELOPMENT OF A COMBINED METHOD FOR FORECASTING ELECTRICITY CONSUMPTION OF AN INDUSTRIAL ENTERPRISE LLC EVROSNAR. *World Bulletin of Social Sciences*, *8*, 57-64. Retrieved from https://www.scholarexpress.net/index.php/wbss/article/view/715

5. Бозоров М. Б. и др. Разработка метода оценки эффективности системы электроснабжения промышленных предприятий //Приоритетные направления инновационной деятельности в промышленности. – 2021. – С. 42-45.

6. Бозоров М. Б. и др. РАЗРАБОТКА МЕТОДА ОЦЕНКИ ЭФФЕКТИВНОСТИ СИСТЕМЫ ЭЛЕКТРОСНАБЖЕНИЯ ПРОМЫШЛЕННЫХ ПРЕДПРИЯТИЙ //ББК 3 П27. – 2021. – С. 42.

7. Бозоров М. Б. ИССЛЕДОВАНИЯ ЭНЕРГОЭФФЕКТИВНОСТИ СИСТЕМЫ ЭЛЕКТРОСНАБЖЕНИЯ ОБЪЕКТОВ ЭНЕРГОСИСТЕМ НА ОСНОВЕ ОБОБЩЕННЫХ ПОКАЗАТЕЛЕЙ ЭФФЕКТИВНОСТИ //ББК! 1 Р76. – 2018. – С. 69.

8. Бозоров М. Б. ИССЛЕДОВАНИЯ ЭНЕРГОЭФФЕКТИВНОСТИ СИСТЕМЫ ЭЛЕКТРОСНАБЖЕНИЯ ОБЪЕКТОВ ЭНЕРГОСИСТЕМ НА ОСНОВЕ ОБОБЩЕННЫХ ПОКАЗАТЕЛЕЙ ЭФФЕКТИВНОСТИ //Российская наука в современном мире. – 2018. – С. 69-71.

9. Н.Н.Садуллаев., А.Х.Шобоев., М.Б.Бозоров., А.Т.Паноев Оценка эффективности системы электроснабжения методом многокритериального анализа. Europaische Fachhochschule. Volume: 08 /2016. URL: https://elibrary.ru/item.asp?id=27542998

10. Садуллаев Н. Н., Шобоев А. Х., Бозоров М. Б. ИССЛЕДОВАНИЕ ВЛИЯНИЯ РЕГУЛИРОВАНИЯ ПАРАМЕТРОВЭЛЕКТРОЭНЕРГИИ НА ВЫБОР ОПТИМАЛЬНОЙ СХЕМЫ ЭЛЕКТРОСНАБЖЕНИЯ //Современные инструментальные системы, информационные технологии и инновации. – 2014. – С. 28-32.

11. Садуллаев Н. Н. и др. Оценка эффективности системы электроснабжения методом многокритериального анализа //Europaische Fachhochschule. – 2016. – №. 8. – С. 36-39.

12. 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.

13. Bozorov M. B. et al. USE OF RENEWABLE ENERGY SOURCES FOR LOW-POWER ENTERPRISES IN UZBEKISTAN //British View. – 2022. – Т. 7. – №. 3.

14. Хафизов Х. И., Бозоров М. Б. Разработка метода комплексного исследования энергоэффективности системы электроснабжения промышленных предприятий //СЛУЖЕНИЕ НАУКЕ. – 2021. – С. 12-19.

15. Sadullayev N. N., Bozorov M. B., Nematov Sh N. Research of Efficiency of Functioning of System of Electro Supply of the Enterprise by Method Multi-Criterial Analysis //Journal of Electrical & Electronic Systems. – 2018. – Т. 7. – №. 2. – С. 18-20.

16. Hafizov K. I., Bozorov M. B. Razrabotka metoda kompleksnogo issledovaniya energoeffektivnosti sistemy elektrosnabzheniya promyshlennyx predpriyati //Sbornik statey Mejdunarodnogo nauchno-issledovatelskogo konkursa. Petrazavodsk, Russia. – 2021. – С. 10-19.

17. Sadullaev N. N. et al. Sistema monitoringa elektropotrebleniy predpriyatiya na osnoe koeffitsienta effektivnosti sistemy elektrosnabzheniya //Europaische Fachhochschule. – 2016. – Т. 8. – С. 40-43.

18. Sadullaev N. N. et al. Evaluation of the effectiveness of the system of electrical supply by the method of mnogokriterialnogo analysis //Europaische Fachhochschule. – 2016. – T. 8. – C. 36-39.

19. Садуллаев Н. Н., Шобоев А. Х., Бозоров М. Б. Информационная инфраструктура «интеллектуальной» сети на основе коэффициента технической эффективнос ти системы электроснабжения //Узбекский журнал Проблемы информатики и энергетики. – 2014. – №. 1-2. – С. 92.

20. Sadullaev N. N., Kh S. A., PARAMETROVELEKTROENERGII B. M. B. I. V. R. NA VYBOR OPTIMALNOY SCHEMY ELEKTROSNABJENIya //Sovremennye instrumentalnye sistemy, informatsionnye tehnologii i innovatsii.-2014.-S. – C. 28-32.

21. 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.

22. Хафизов И., Махсум Б., Жабборов А. ИССЛЕДОВАНИЕ ПРИМЕНЕНИЯ СОЛНЕЧНЫХ ПАНЕЛЕЙ ДЛЯ ПИТАНИЯ КАТОДНОЙ СТАНЦИИ МАГИСТРАЛЬНОГО ТРУБОПРОВОДА ГАЗЛИ-КОГОН //Innovations in Technology and Science Education. – 2023. – Т. 2. – №. 9. – С. 1907-1917.

23. Panoev, A., & Bozorov, M. (2024). Algorithm of Energy Saving by Compensating the Reactive Power of Asynchronous Motors Used in Feed Grinding Devices. *Miasto Przyszłości*, *55*, 790–798. Retrieved from https://miastoprzyszlosci.com.pl/index.php/mp/article/view/5733

24. Bozorov M. FORECASTING ELECTRICITY CONSUMPTION OF MERGANTEX ENTERPRISE //Modern Science and Research. – 2023. – Т. 2. – №. 5. – С. 605-612.

25. ISTE'MOLINI M. K. E. E., QILISH P. MODERN SCIENCE AND RESEARCH //MODERN SCIENCE. – 2023. – Т. 2181. – С. 3906.

26. Islam X., Maxsum B., Shaxzod Z. SANOAT KORXONALARI TRANSFARMATORLARINING SAMARADORLIGINI BAHOLASH //Innovations in Technology and Science Education. – 2023. – Т. 2. – №. 9. – С. 1930-1942.

27. Panoev A., Bozorov M. ANALYZING THE EFFICIENCY OF INDUCTION MOTOR REACTIVE POWER COMPENSATION IN FODDER GRINDING DEVICES