

Energy-Efficient Electrical Systems for Water Pumping Stations

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Abstract. In this article, the possibilities of using energy-efficient electric motors at pumping stations providing water supply in agriculture are studied. The research was carried out on the base of existing pumping units in Andijan region. Analyzed energy saving performance by introducing high efficiency drives, frequency control devices and automated systems.

INTRODUCTION

The agricultural sector in the Republic of Uzbekistan is considered one of the strategic directions of the economy and plays an important role in sustainably providing the population with food products, increasing export potential, and creating new jobs [1, 3]. A large part of the country's irrigated land is irrigated through pumping stations, which places high demands on the reliability and energy efficiency of pumping units in the water management system [3, 6, 9]. In particular, the hydromelioration infrastructure in Andijan region has more than 130 pumping stations, through which water is supplied to more than 100,000 hectares of irrigated land every year. Currently, most of the electric motors used in these stations are outdated, with an efficiency coefficient of around 70–75%, and are characterized by high energy consumption, complex maintenance, and non-automated control systems. This causes excess consumption of total electricity, increased operational costs and interruptions in the production process [2, 3]. According to the analysis of 2024, the total electricity consumption of pumping stations in Andijan region will exceed 150 million kWh per year. About 25–30% of this is lost due to technical inefficiencies, i.e. outdated practices and inappropriate operating modes. Also, the reliability of pumps remains at a low level due to power outages and overheating of engines during the production process [2, 3].

The efficiency of water supply in the agricultural sector directly depends on the reliability and energy efficiency of water pumping units. Existing pumping stations in Uzbekistan have been operating since the middle of the century and are often based on asynchronous drives of the AER type, which have low efficiency [3, 4]. Such aggregates are characterized by high energy consumption, rapid heating during operation and mechanical damage. Therefore, replacing them with modern energy-efficient methods is an urgent task [4].

RESEARCH OBJECT AND METHODOLOGY

Researches were conducted at pumping stations located in Jalayor, Khojaabad and Kurgantepa districts of Andijan region. At these stations, the AIR-75 kW electric drives were replaced with energy-efficient IE3 type drives and the speed was adjusted to the automatic control system using frequency converters [5, 6].

Equipment used:

- Energy monitoring devices (energy meters)

- Tachometers of rotation speed
- Frequency control device (VFD)
- PLC-based automated control system

Table 1. Experiment results and analysis

Indicators	Previous situation	An updated status
Drive type	AIR-75 kW	IE3-75 kW
Water delivery (m ³ /hour)	430	455
Average energy consumption (kWh)	78	60
Energy conservation	—	~23%
Heating temperature (°C)	72	58
Vibration level? mm/s	3.2	1.1

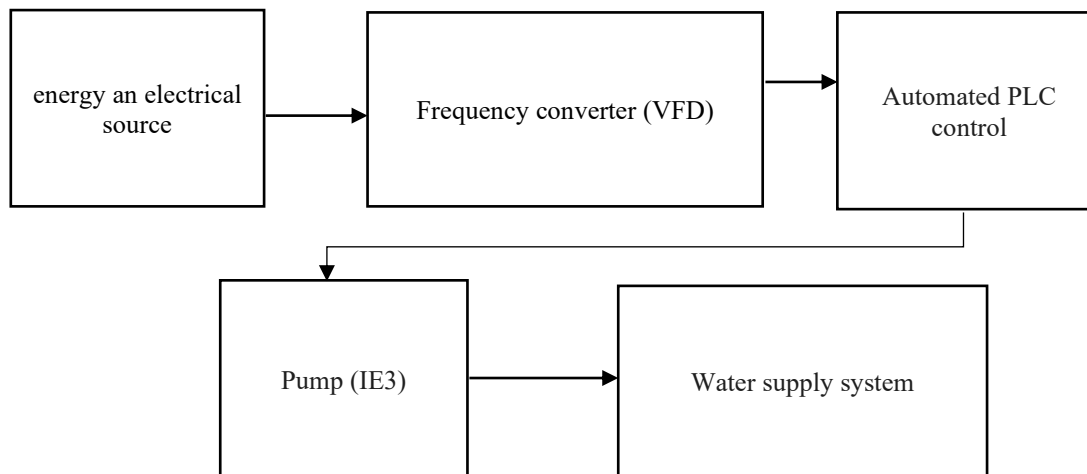


FIGURE 1. Frequency block control system scheme

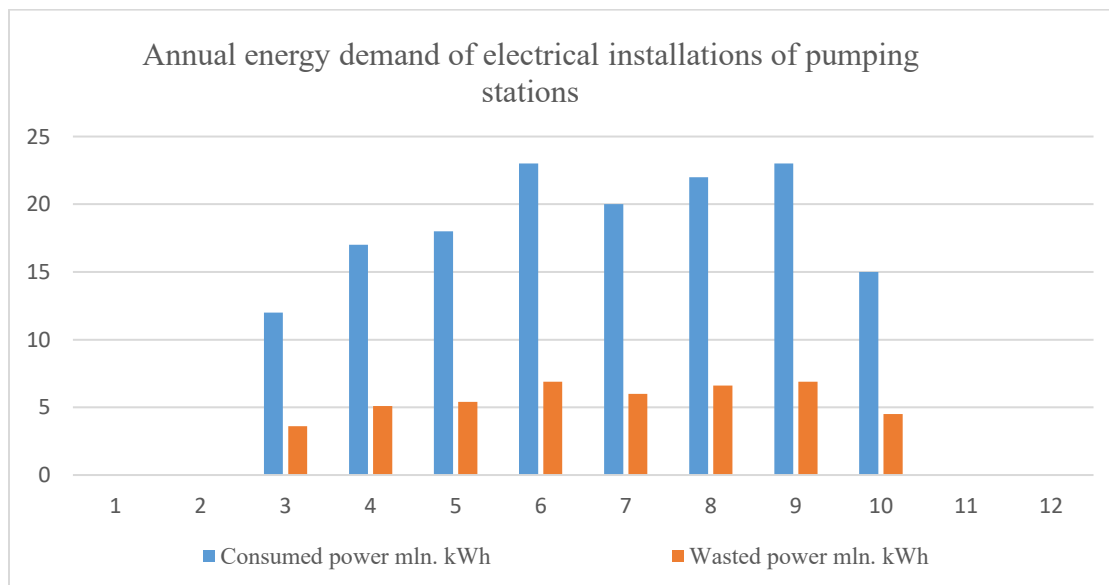


FIGURE 2. Indicators of the annual demand and loss of electric energy of pumping stations in Andijan region

SCIENTIFIC NOVELTY AND PRACTICAL SIGNIFICANCE

- Scientifically calculated relationship between power-speed-water requirements automated using inverters.
- The research results in real conditions were demonstrated in the practice area for students [7, 8].
- Continuity and efficiency in water supply have been increased by optimizing the pump units.

SUGGESTIONS

1. It is necessary to gradually introduce IE3 or higher type drives at pumping stations in the Andijan region.
2. By using frequency control devices, water supply can be automated according to demand.
3. Regular technical diagnostics of pump units ensures energy savings.
4. It is desirable to establish laboratories in educational institutions to demonstrate energy-saving systems in practice [10, 11].

EXPECTED RESULTS

- 30-40 million kWh of energy is saved per year in water management facilities in Andijan region;
- Operating costs are reduced by 20-25%;
- Reliability and continuous operation of pumping stations is ensured;
- Farmers' farms in the region will be provided with stable water supply, and irrigation efficiency will increase.

CONCLUSIONS

The use of energy-efficient electric drives in water pumping stations is an important factor in the sustainable development of agriculture not only in the Andijan region, but also throughout the republic. Through a scientifically based approach and technological modernization, high results can be achieved by reducing electricity consumption, increasing technical reliability and digitizing the irrigation system.

REFERENCES

1. Norboev, A. (2024). *Speed regulation of asynchronous machines using mathematical modeling*. ResearchGate. https://www.researchgate.net/publication/390418162_SPEED_REGULATION_OF_ASYNC_HRONOUS_MACHINES_USING_MATHEMATICAL_MODELING?utm_source=chatgpt.com
2. Karimjonov, D., Makhudov, M., Xalimjanov, A., Abdukhalilov, D., Axmedov, D., & Mamajonov, X. (2024). *Modeling the structures of three-phase asynchronous motor reactive power variations using electromagnetic transducers*. AIP Conference Proceedings, 3244(1), 060018. <https://doi.org/10.1063/5.0241567>.
3. Berdiyev, U. T., Sharapov, Sh. A., Norboev, A. E., & Beytullaeva, R. X. (2024). *Study of the speed control system for asynchronous machines by changing the frequency using mathematical modeling*. In 15th International Conference on Thermal Engineering: Theory and Applications, Tashkent, Uzbekistan. <https://journals.library.torontomu.ca/index.php/ictea/article/download/2169/1949/11079>
4. Berdiyev, U. T. (2024). *Energy efficiency of electric motors based on powder technology*. In 15th International Conference on Thermal Engineering: Theory and Applications, Tashkent, Uzbekistan. <https://journals.library.torontomu.ca/index.php/ictea/article/view/2200/1946>
5. Berdiyev, U. T., Jiyankulov, L. A., & Abdurakhmanov, N. T. (2024). *Energy-efficient artificial loading schemes when testing an asynchronous motor*. Journal of Thermal Engineering, https://journals.library.torontomu.ca/index.php/ictea/article/view/2163/1934?utm_source=chatgpt.com
6. Mamajonov, X. (2023). *Thermal model of an induction traction motor*. Ekonomika i Sotsium. https://www.iupr.ru/_files/ugd/b06fdc_fdb9d24ea31849a799854774eb81c58c.pdf?index=true&utm_source=chatgpt.com
8. U.T. Berdiyev¹, N.A. Samatov², H. Mamajonov³, D.Akhmedov⁴. ANALYSIS OF TECHNICAL PARAMETERS AND LIMITATIONS OF THE ELECTRIC DRIVE SYSTEM IN PUMPING UNITS. SCIENCE AND INNOVATION INTERNATIONAL SCIENTIFIC JOURNAL VOLUME 4 ISSUE 8

8. Akhmatovich, S. N., et al. (2020). *Calculation of mechanical characteristics and regulation methods of the electric actuator rotation frequency of the air conveyor*. PalArch's Journal of Archaeology of Egypt/Egyptology, 17(6), 3349–3356. https://archives.palarch.nl/index.php/jae/article/view/1321?utm_source=chatgpt.com
9. Samatov, N. (2020). *Selection of flow diagrams of the adjustable thyristor asynchronous electric actuator with phase control*. The American Journal of Engineering and Technology, 2(11), 19–24. https://inlibrary.uz/index.php/tajet/article/download/10336/10768?utm_source=chatgpt.com
10. Samatov, N. (2022). *Closed system of asynchronous electric drive with asymmetric activation of thyristors*. Jundishapur Journal of Microbiology, 15(1), 1573–1578. https://jjmicrobiol.com/index.php/jjm/article/view/271?utm_source=chatgpt.com
11. Samatov, N. A. (2023). *Selection of power circuits of a controlled thyristor asynchronous electric drive with phase control*. Science and Education in Agriculture, 1(2). <http://seagcandqxai.tilda.ws/>