https://doi.org/10.29013/ESR-21-9.10-24-28

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SOFTWARE FOR CONTROL, ACCOUNT AND RATIONAL USE OF GROUNDWATER USING AN AUTOMATED ASYNCHRONOUS ELECTRIC DRIVE FOR WEEP HOLES

Abstract: The article deals with the issues of account, control and rational use of groundwater, using new elements of automated asynchronous electric drive with program control.

Keywords: groundwater, automated electric drive, program control, frequency converter, soft starter, saving resources, saving electricity, pumping station automation, well pumps, holes.

Introduction. One of the key problems humanity will face in the future is the lack of electricity and water. According to experts, the reserves of fresh water necessary for drinking, agriculture and energy production are catastrophically reduced every year. According to the UN (published in June 2018) the shortage of drinking water will be felt as early as 2030, and by 2050 half of the world's population will not have access to clean water. In addition, there is another environmental problem associated with land degradation and soil salinity. Taking into account the data of the International Institute for Environment and Development and the World Resources Institute, about 10% of the continents surface is covered with saline soils, and this value is growing every year [1].

The problem of clean drinking water and the degradation of cultivated lands and pastures also exists in the Republic of Uzbekistan. Land degradation is primarily associated with the natural and climatic features of the region. It is also worth noting that pollution, salinity, erosion, deforestation are associated with human activities.

The intensive development of industry and agriculture over the past 50 years has had a negative impact on the state of fresh groundwater. This led to a reduction in it reserves by 35 percent and the depletion of individual deposits due to unauthorized construction of water intake facilities and uncontrolled water take-off. In some areas of the republic, due to the unsatisfactory condition of the surface water diversion network and drainage systems, the intensive rise in the level of groundwater, as well as the lack of systematic hydrogeological monitoring, some cities and other settlements are sometimes flooded [2].

In recent years, a number of large-scale measures have been taken to provide the population of most regions of the republic with centralized water supply. At the same time, the needs of the population of 69 cities, 335 settlements and 2902 rural settlements are met by groundwater reserves [2].

The legislative base for the prevention of ecological catastrophe has been fixed. One of the recent measures to create an effective system to combat land degradation was the Decree of the President of the Republic of Uzbekistan No. PP-277 dated June 10, 2022 "On measures to create an effective system to combat land degradation". In order to combat land degradation, preserve and restore soil fertility, and prevent desertification, the republic uses advanced scientific developments in this area [3].

In Uzbekistan, there are about 100 groundwater deposits, of which 77 are fresh groundwater. The predicted groundwater resources in the republic with a salinity of up to 5 g/l are 66 million m^3/day, of which with a salinity of 1 g/l is 24.4 million m^3/day. Basically, groundwater is concentrated in the Fergana Valley (34.5%), Tashkent (25.7%), Samarkand (18%), Surkhandarya (9%), Kashkadarya (5.5%) regions [4; 5].

To date, there are more than 27 thousand operating holes for various purposes in Uzbekistan. In 2017, the State Committee of the Republic of Uzbekistan for Geology and Mineral Resources conducted an inventory of more than 10 thousand holes. As a result, it was found that there is no proper control and account for the use of groundwater, the lack of operating pumping stations automation for drainage, ensuring the reliability and uninterrupted operation of their work, etc.

Methods. If we analyze the existing drain wells (vertical, horizontal or combined drainage), designed and operated in the republic, we can conclude that all pumps used to supply water are driven by an asynchronous electric drive. The induction motor, used in both well pumps and horizontal pumps, is the most common electric motor in such installations. This is due to the fact that an asynchronous motor is cheaper, more reliable, and more convenient to operate and repair.

Most of the pumping units operate directly from the network – the pump asynchronous motor is connected to the electrical network directly through the switching equipment. At the same time, it should be noted the presence of large hydraulic shocks, mechanical overloads and over-starting currents, which adversely affect the operation of the pump, electric motor and electrical substation. It is high starting currents that can make it impossible to use alternative energy sources to power remote weep holes, since they require a larger power reserve. The lack of automation at existing holes leads to unreasonable water take-off. As a result, electricity is consumed, since the pump works around the clock.

Results and Discussion. In this article, the authors propose the improvement of the existing system of weep holes. The purpose of the modernization is to optimize the consumption of electricity by pumps, monitor and control the level, volume, as well as the quality or degree of salinity of water in holes.

Figure 1. A general view of the control cabinet

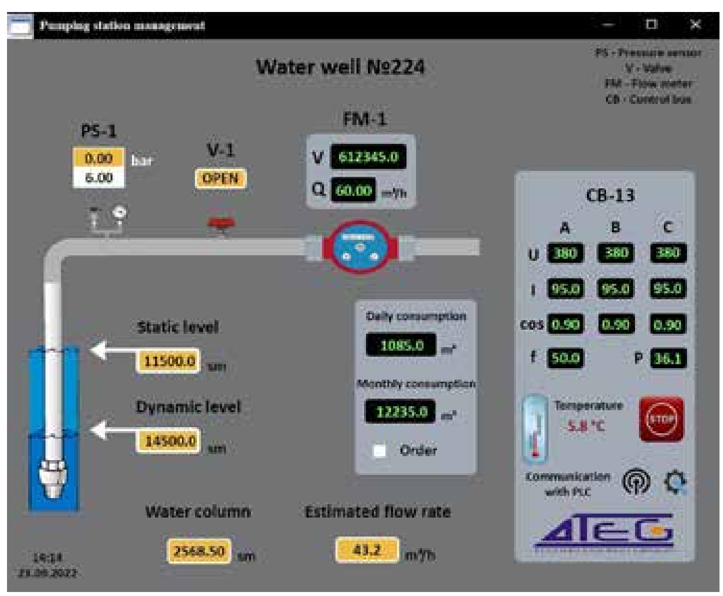

Figure 2. A general view of the software package for a pumping station with a well pump

Figure 1 shows a general view of the control cabinet and automation of the pumping station, Figure 2 shows a general view of the software package for a pumping station with a well pump "Monitoring, control and management of groundwater parameters".

The pumping station control cabinet is designed for switching the pumping unit (enable/disable), protection against abnormal modes (for example, overload, phase failure, deviation from the nominal values of the supply voltage, "jamming" of the shaft of the well pump), transferring the status of the pumping unit and operating parameters of the pump, transferring the state of the hole (water level, current flow rate of the hole (debit), temperature, composition of water salinity) over long distances (Fig. 3).

The control and monitoring cabinet includes:

– switching and protective equipment (circuit breakers, contactors, phase control relays, etc.);

– energy-efficient soft starter and speed control of asynchronous motor;

– a modem for transmitting information over distances;

– a programmable controller for interconnecting the cabinet with sensors and transmitting information to the control room;

– external water level control sensors, flow meter, water temperature and salinity sensor.

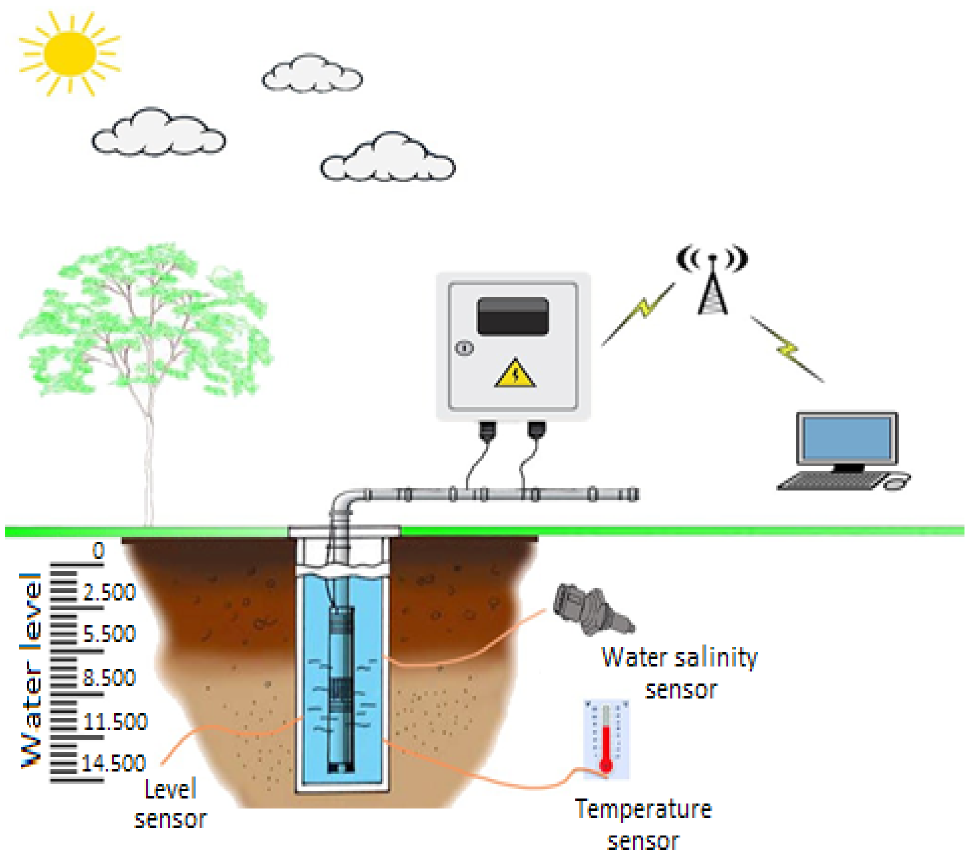

Figure 3. General view of the interaction of the pumping station with the control room

A distinctive feature of the pump control system from the existing ones are the following features:

– soft start of the pumping unit. The need for a soft start is primarily associated with extending the life of the motor and the pumping unit as a whole. As you know, asynchronous motors are started with large starting currents, which exceed the nominal value by 5–7 times. This leads to a rapid aging of the winding insulation and a decrease in the mains voltage. Direct start of the pump is associated with mechanical loads on the pump shaft and bearing assemblies. Ensuring a smooth start of the pumping unit eliminates these disadvantages.

– regulation of the volume of water produced from the hole within a wide range by regulating the speed of rotation of the asynchronous electric motor of the pump.

Compared to the operation of existing electrical control cabinets, this pump operates in discrete mode. When the water level reaches the upper level, the pump automation turns on the electric motor. After the time has elapsed, the water level drops, automatics work and the pump turns off. Thus, the required level of groundwater is maintained with periodic switching on and off of the pump.

The control cabinet with an energy-efficient asynchronous electric drive operates as follows. At the moment the pump is turned on, the asynchronous motor of the pumping unit starts smoothly, without jerks, the starting current does not exceed the rated value. This is achieved through the use of frequency regulation by an asynchronous motor. Depending on the water level in the hole, the pump starts to work at a certain speed. At the initial moment, the pump rotation speed will be maximum. As the water level decreases, the speed of the pump rotation, and, accordingly, the volume of liquid pumped out will decrease. In fact, the operation of the hole can be balanced and the water level can be maintained at the same value. The dynamics of the hole operation becomes continuous, the fluctuation of the groundwater level is reduced compared to operation in the usual discrete mode without controlling the pumping unit speed. Also, it should be noted that with a decrease in the speed of the pumping unit rotation, the electric energy consumed by it also decreases in a cubic dependence. In practice, the average speed of the pumping unit is at the level of 35–45 Hz. The expected average saving of electric energy in the hole can be at the level of 30–40% [6].

Conclusion. Modern level gauges installed in the hole, sensors of dry running, temperature, water salinity, connected to the pumping station control system can provide the necessary information about the state of groundwater.

The presence of a programmable controller and a modem for communication can remotely transmit information to the control room and control the automation of the system.

The software of the system for monitoring, control and rational use of water resources allows continuous polling of several hundred holes, clarifying the hole flow rate and processing the received data.

The automated system will provide:

– remote control of turning on, turning off and adjusting the speed of the pumping unit;

– monitoring and control of hole parameters, such as water level, temperature, current flow, electrical parameters of the network, such as voltage, current, power consumption, etc.;

– saving electricity and water resources (by adjusting the speed of the pump, the consumption of electrical energy changes and water extraction becomes more rational);

– automatic recording of hole parameters, its archiving, etc.

The widespread introduction of domestic development will make it possible to rationally approach the issues of groundwater level control, obtain savings in electrical energy and water resources, and gradually switch to alternative power sources for underground holes. In addition, it is possible to equip not only pumping stations with this equipment, but also manholes for high-quality monitoring of groundwater.

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