AUTOMATIC MONITORING AND CONTROL OF GROUNDWATER LEVEL

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Abstract

The purpose of this paper is to analyze automatic protection and control measures at pump stations in the event of constant accumulation of groundwater and water dripping from the pump, leading to flooding in the pump station engine room. To prevent this, the pumping station's machine room should monitor the level of groundwater and water leaks from the pump, and in a timely manner automatically remove excess water with a pump. The excess water is collected in special reservoirs. From these the ERSU series sensor which is based on a contact electrode controller does not allow it to constantly monitor the level in the storage tank within the required limits, therefore, as a completely automated system it is unstable, and does not have the ability to support the regulatory requirements for preventing it from starting one of its technical operations. The article discusses the positive aspects of technical solutions and experimental work in the DRV5023 IC with MSP430G2131 controller and no more than 2.7 mA consumer, NE555 IC based timer and pump mode, stable contactless sensor, sensor-based automatic monitoring and pumping system. The results are given. (12-17 seconds.) Preparation to start the pumping process is also a standard 4.7 V. power supply circuit. The work is based on production experience and is innovative.

Introduction. Many years of experience and the observations of the authors of this work in the field of production operation of energy and automation equipment of pumping stations made it possible to establish noticeable improvements to the structure of auxiliary technological processes and operations, especially in matters of protection of equipment and the production process taking place in the engine room of a pumping station from open water are possible. The efficiency of operation of pumping stations, as well as sustainable protection against the flooding of its premises, including the station's engine room, depends entirely on the reliable operation of submersible pumps that provide drainage water pumping. Under production conditions, submersible pumps of some stations, for various reasons, are not able to provide a complete removal of drained water. In addition to drained water in the engine room, there are leaks from pumping units, the origin of which is not considered in this paper, but their volume, together with the water not drained by submersible pumps, makes it necessary to make additions to the structure of the technological process in the engine room to protect the latter from flooding. These additions can be attributed to auxiliary processes, but they are able to provide reliable protection of the machine room from flooding.

Materials and methods. The general structure of the functioning of the pumping station includes several technological sections, which are of an auxiliary nature, and provide conditions for technical and technological

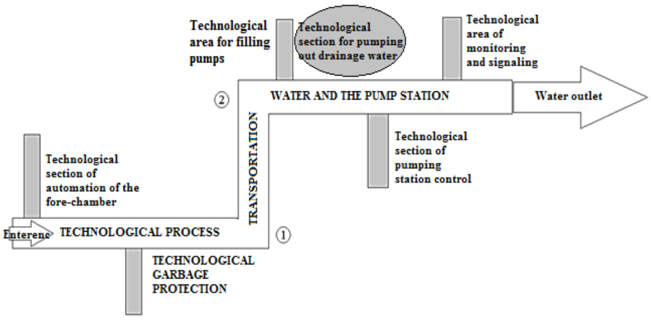

Figure 1. Technological sections in the technical process of transporting water at a pumping station.

operation and safe operation of electrical equipment. Such a site includes a technological section for pumping out drainage water (TUODV), (Fig. 1). In general, these sites are distributed at two levels of water transportation. At the first level of the suction pipeline there is a section of the fore-chamber and a technological section of garbage protection and fish protection. On the second level of the pumping station premises there are technological sections for pumping pumps, pumping out drainage water, a control section, a monitoring and a signaling section at the pumping station. The equipment and means of automation of the technological section for pumping out drainage water include: a well, a submersible pump, a submersible pump control station, and outlet pipes. At the same time, at some pumping stations: Kibrai-TashGres in the Kibray district, Ramadan in the Zangiota district, Chirchik in the Bostanlik district, Boz-suv in the Chinaz district of the Tashkent region, within the framework of the technological section for pumping out drainage water, form an additional section in as part of a storage tank for drainage water and water flowing into the storage tank from leaks of working pumping units, an electrode regulator, a level indicator in the storage tank, a horizontal centrifugal pump for pumping water from the storage tank. The controller-indicator performs two technological operations: signaling the emergency state of the level in the storage tank, and automatically connecting the pump for pumping water [1]. Thus, the storage tank is a deep water collector in which, to prevent flooding of the pumping station, drained water and leaks are collected, and with the help of a signaling regulator, it is pumped from there.

If this is not done, the water from the reservoir will heat up the engine room of the pumping station. The practice of operating the technological process constructed in this way has shown that the electrode signaling device-level controller (ERSU), which is part of the TUODV, has the disadvantages of relay-contact origin, and, like the signaling device, is notable for its inability to continuously monitor the level. These shortcomings are manifested in conditions of high humidity affecting the electronic relay unit of the ERSU. In addition, the lack of continuous measurement of the water level in the reservoir does not allow one to have information prior to the moment the pumping pump is switched on, as required by the established operating standard at the pumping station [2,3]. Namely - the operator for 12-17 s. must be aware of the start of this operation before turning on the suction pump. Also, some electrodes operated as part of the TUODV at the pumping stations in Uzbekistan, the level signaling device, although they are made of the appropriate alloy steel, however, over time, they are subjected to biological "raids" and further corrosion, which significantly affects the reliability of the entire technological section of water pumping. As a result, water accumulates at pumping stations in the engine room and floods the pumping station, which leads to a long-term shutdown of pumping units. There are cases when the flooding of the machine room led to the burnout of the electric motor of the pumping unit and the complete failure of the electrical network of the pumping station [3,1]. Formulation of the problem. Taking into account the state of the issue with the indicated shortcomings arising from the operation of the TUODV, the possibilities were studied and proposals were made for the use of automation tools for pumping out pumping stations from flooding and control using a non-contact level sensor built on the principle of the Hall effect and schematic solutions at the technological site for pumping out drainage water providing established technological requirements. As is known, various sensors are built on the Hall effect, including level sensors [4,5]. Figure 2. shows the proposed functional diagram of continuous monitoring of the water level in the storage tank TUODV pumping station, based on the Hall sensor and pumping water from the tank.

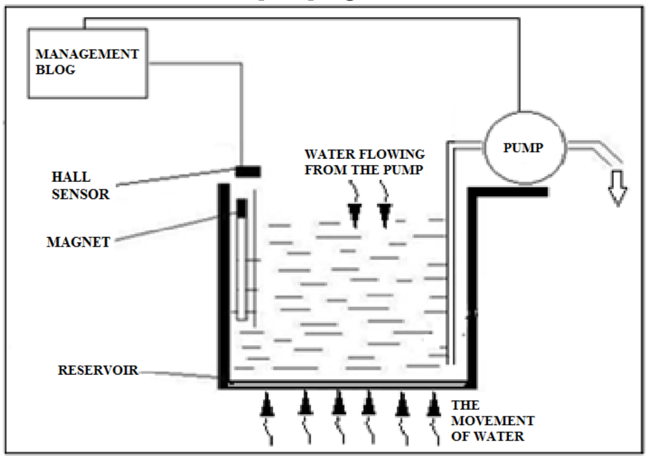

Figure 2. Functional diagram of automatic control and pumping of water from the reservoir.

Auxiliary technological area for pumping water, (Fig. 2), works as follows. In an arranged built - storage tank, water is collected from leaks of pumps from the machine room of M.Z. and non-diverted drained water D.V. This water must be pumped out to prevent it from overflowing through the reservoir and flooding the pumping station. The Hall sensor is permanently installed on the inner wall of the tank above the magnet with a float. An increase in the water level in the tank leads to the approach of the magnet to the sensor, and at a critical level value, through the control unit B.U. the centrifugal pump Ts.N. and water is pumped out of the reservoir and discharged from the premises of the pumping station.

Results and discussion. The solution methods in this work involve the use of the features of the operation of the Hall sensor at the time of entry / exit into the operating mode of measurement, the aggregation of circuit designs in the control unit, the autonomy of the monitoring and control system, the minimum power consumption, as well as mobility at a low cost compared to with ERSU regulator. Figure 3 shows a schematic diagram of the operation of the Hall sensor with the MSP430G2131 controller on the DRV5023 IC [6,7]. Using it with a low power-consuming microcontroller, it is possible, thanks to a combination of software and hardware capabilities, to implement a battery-powered sensor [8,9], or with an autonomous standard 4.7 V power supply.

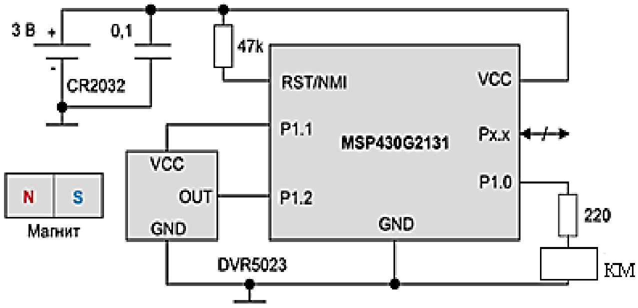

Figure 3. Schematic diagram of the operation of the Hall sensor with ultra-low power consumption.

An example of technical implementation involves connecting the Hall sensor directly to the microcontroller outputs and (if necessary) periodically turning it on for measurement. This mode can significantly reduce the load on the power supply [9,10]. The purpose of this solution is to reduce the average current consumption by reducing the active time of the sensor itself.

The longer the sensor inactivity time, the lower the average current consumption of the circuit [10]. The use of microcircuits of the DRV5023 family [12] made it possible to have low current consumption (2.7 mA) of electricity, and did not require an additional stabilizer, and also provided a fast turn-on time (35 µs).

Consider the operation of the recommended device when the water level in the tank drops, after turning on the pump. The sensor, which has a float with the magnetic part descending, is brought to the exit system and its properties change[13,5]. At the same time, as field observations have shown, due to high sensitivity, fluctuations in falling levels and, in some cases, rapid filling of the tank, there are repeated switching on and off of the pump motor. In general, this provokes unstable operation of the automatic pump control system. To prevent these phenomena, a timer built on the basis of the NE555 microcircuit was introduced into the monitoring and control system (Fig. 4) [14]. This made it possible to create a stable operation of the pump motor until the tank was completely empty. At the end of the timer, the system switches to work from the level sensor. That is, the reservoir begins to fill and the process repeats again. It should be noted that on the timer it is possible, using the potentiometer R1 (Fig. 4), to adjust the shutdown time of the actuator (pump motor), thereby changing the duration of the pump, that is, manually set the timer output algorithm in the range from 1 to 25 seconds. And this, in turn, allows you to solve automatically the technological operation of notifying personnel about the completion of the pumping, and to form a 12-17 second readiness mode for turning it on to start pumping water. Technically, this is done (Fig. 4) by installing in series with a constant resistor of 10 kΩ a variable potentiometer with a nominal value of 250 kΩ. The electrical capacitance of the time-setting capacitor is 100 microfarads.

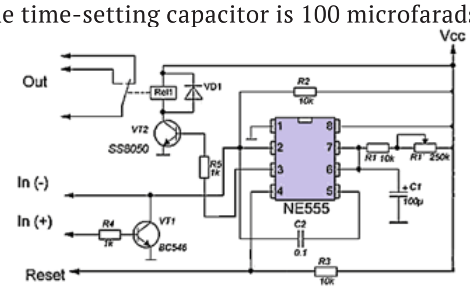

Figure 4. Schematic diagram of the timer on the ne555 chip.

The timer circuit works as follows. In the initial state, pin 2 has a high level: logic 1 (from the power source), and pin 3 has a low level: logic 0. Transistors VT1, VT2 are closed. At the moment a positive pulse is applied to the base VT1, a current flows through the Vcc-R2-collector-emitter-common wire circuit. VT1 opens and puts the NE555 into timing mode [14]. At the same time, a positive pulse appears at the output of the IC, which opens VT2. As a result, the emitter current VT2 leads to the operation of the relay. If necessary, maintenance personnel can interrupt the task at any time by briefly shorting Reset to ground.

CONCLUSIONS. Thus, the experience of operation and observation of the processes occurring in the engine room of pumping stations indicates the need to form an auxiliary process in it with instruments and equipment to remove drainage water and pump volumetric leaks in order to avoid flooding of the engine room. The results of studying the possibilities of automation of control and protection against such flooding made it possible to create and conduct laboratory tests of a local set of tools that provide the specified auxiliary automated technological process, including: a storage tank, controls, instrumental control of drained water and leaks in the tank, a horizontal centrifugal pump for automatic removal of excess water, as well as means of generating an alarm to notify the dispatching service about the state of the mode of this process. The complex includes: contactless level sensor - Hall, with the MSP430G2131 controller on the DRV5023 IC and the current consumption is not more than 2.7 mA; a timer based on the IC NE555 that ensures stable operation of the automatic pumping control system and a 12-17s mode. readiness to start the pumping process; standard 4.7 V power supply.

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