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TÍTULO: Automatización de instalaciones de agua en Kazajstán y sus soluciones.

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RESUMEN: En el nuevo entorno de desarrollo agrícola, la gestión del agua en la agricultura, como uno de los principales factores que garantizan una producción agrícola altamente estable, desempeña un papel especial. La novedad científica de la investigación es la mejora del sistema automatizado para controlar la gestión de los recursos hídricos y medir el agua de manera oportuna y equilibrada. Esto permite obtener información sobre las descargas, cuyo análisis permite establecer si se ha logrado el objetivo principal de la distribución de agua y si la cantidad de agua requerida se ha suministrado a tiempo. Como resultado, se implementó el sistema automatizado de medición de recursos hídricos, monitoreo de nivel y control en los complejos hidráulicos de Asa, Tasotkel y Terisaşçıbulaq en Kazajstán.

PALABRAS CLAVES: Medición de agua, sensor de nivel de agua, medición de descarga, gestión automatizada de agua, instalaciones de agua.

TITLE: Automation of water facilities in Kazakhstan and its solutions.

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ABSTRACT: In the new environment of agricultural development, agricultural water management, as one of the main factors guaranteeing high stable agricultural output, plays a special role. The scientific novelty of the research is the improvement of the automated system for controlling water resource management and metering water in a timely and balance fashion. This enables getting information about discharges, the analysis of which allows to establish whether the main goal of water distribution has been achieved and whether the required amount of water has been supplied in time. As a result, the automated water resource metering, level monitoring, and control system was implemented at the Asa, Tasotkel and Terisaşçıbulaq hydraulic complexes in Kazakhstan.

KEY WORDS: water metering, water level sensor, discharge measurement, automated water management, water facilities.

INTRODUCTION.

At the present time, when water has become an expensive commodity, for the rational and efficient operation of irrigation systems, day-to-day and just water metering should be made, as well as hydraulic structures in canals should provide a supply of preset discharges.

Water metering systems provide quantitative control of technological processes of water use management (water distribution). In this regard, there is a need to expand the functionality and increase the requirements for the technical characteristics of measuring instruments. This is technically and economically feasible since the organization of commercial water metering and the subsequent use of automated control systems will require the introduction of instruments for measuring the parameters of water flow into the overall water use instrumentation complex.

Thus, developments made in this area should be based on new approaches to the organization of operation including the planning and management of water use and distribution, as well as forming systemic water metering based on technological advances in measurement technology and metrology.

The practical value lies in the development and implementation of:

- Automated system for metering water and controlling water resource management at the Asa, Tasotkel and Terisaşçıbulaq hydraulic complexes in the Jambyl Region;
- Recommendations on improving the automated system for metering water and controlling water resource management in the regions of Kazakhstan.

Developed recommendations for improving the automated system for metering water and controlling water resource management can be used by operational water management organizations, as well as by standardization and metrology bodies during the calibration and examination of water measurement instruments.

The research is aimed at improving the water measurement instruments and automated water management systems at hydraulic complexes to increase the efficiency of water use operation of water control and metering network facilities.

DEVELOPMENT.

The research methodology and methodological support of research are aimed at the development and implementation of innovative technologies of the process control improving water metering methods for irrigation systems in the Republic of Kazakhstan. The research methodology includes field and theoretical research for the creation of new innovative technologies, the organization of testing and adjustment of patented technological equipment designed to meet the needs of the industry.

In this regard, the research methodology includes the formulation of the problem, a description of the objects, the subject, the program, their goals, ways and means of solving problems.

The technical and operational condition of the equipment was examined in accordance with the requirements of GOST (Bochkarev, 2012; GOST 34.201-89, 1990; GOST 34.320-96, 2001; GOST 34.601-90, 1992; GOST 34.602-89, 1990; GOST 34.603-92, 1993; RD 50-34.698-90, 1993). The performance of existing automated water metering systems of the irrigation systems in Kazakhstan (in Zhambyl, South Kazakhstan, Kyzylorda, Almaty, Aktobe, and East Kazakhstan regions) was evaluated. In the course of the research, the study of the processes occurring at water facilities was made; the possibility of upgrading the existing systems of water metering and automated transfer of initial information to the dispatch console and its processing was assessed and the ways to implement it were considered.

When processing research materials at the office, domestic water metering technologies were compared with existing foreign counterparts and the degree of automation integration was determined. On the basis of the data obtained, the main functional and user requirements for the equipment to be automated have been identified.

The survey of technical and operational condition, the evaluation of the work of existing automated water metering systems of irrigation systems, the research of the industrial process occurring at the water management facility, the assessment and the consideration of the ways of the implementation of the possibility of upgrading the existing systems of water metering and automated transfer of initial information to the dispatch console were carried out in the following sequence:

- Collection, systematization, and analysis of initial data about the equipment to be automated;
- General analysis of water metering technologies and the peculiarities of their implementation;
- Assessment of the technical condition of the facility (the state of the existing network infrastructure, server equipment, and workstations);
- Description of existing automated control system and primary automation equipment.

The research was carried out in accordance with the current regulatory documents and approved methods, norms and rules of technological and environmental safety, as reflected in the laws of the Republic of Kazakhstan and ISO 9001 (GOST 34.201-89, 1990; Kolodyazhny, 1990).

Improving and implementing innovative technologies that have innovative patents for an invention related to irrigation systems with a large number of parameters and complexity of control algorithms requires comprehensive studies on the optimization of industrial processes.

The Asa, Tasotkel and Terisaşçıbulaq hydraulic complexes in the Jambyl Region, as well as other hydraulic complexes in Kazakhstan, are the focus of research.

The subject of research includes innovative solutions to streamline water management processes based on water-saving technologies, developing and implementing modern technical, software and information automation tools.

Research in the field of automation should solve the problem of monitoring and managing the parameters of water flows, collecting, processing, storing and providing information for the rapid distribution of water resources with the use of modern technological equipment and engineering solutions.

The efficiency of water facilities depends largely on the conditions of their operation, maintenance, timely repair, and reconstruction. The main activities aimed at improving the operation of water facilities, of which hydraulic structures are a part, are presented as follows: the development of a rational structure of management and the organization of facilities management service; scientific organization of labor based on the implementation of best practices; improvement and development of automated control systems for hydraulic structures.

At this stage, information was collected about the existing industrial process in the facilities under research, process automation system (PAS) and possible ways of modernization.

The monitoring of the water resources management system at hydraulic complexes in the regions of the Republic of Kazakhstan was carried out. The analysis of the monitoring of the state of water management systems made it possible to analyze the results of water use, which enabled obtaining the same qualitative and quantitative results as before. The useful water saving, the reduction of the water use cost, and the ensuring of environmental requirements enabled improving of water security, reducing possible adverse effects of human factors, saving the metering data in the memory of the processor or sending them to a central server for storage, which, in turn, can provide the meter data to all relevant operators, auditors and public organizations.

In the new economic environment, for the organization of water use, fundamentally different technologies and technological equipment are required to obtain timely and reliable data on the state of agricultural water management facilities based on new developments in the field of information support of industrial processes.

Further development of system water metering is inextricably linked with the use of new general-purpose measuring instruments. The technical and metrological capabilities of such measuring instruments and equipment are so great that the development of new technologies for their use with the irrigation networks (IN) is required.

The objective of this stage is the improvement of the existing device DUV 2/0,005-5 (a water level sensor). This improvement will speed up the transition to an automated observation system, obtaining hydrological information and increasing the efficiency of its use.

An important task of this stage is also the registration of this device in the register of new equipment and facilities in the Republic of Kazakhstan.

To implement the device, a series of scientific studies were carried out with hours of trouble-free operation and with an instrumental verification of the device performance at existing gauging stations.

In the course of scientific research, the optimization of the design and technical parameters of the device was conducted, i.e. measures have been taken to improve the sensor's performance:

- Technical fine-tuning of the device for managing information about the operation of the water metering device.

- Processing configuration and control commands coming from the server.

- Insertion of a backup data storage device (a microSD) into the sensor.

- Initialization.

- Registration of the sensor in the system and automatic transition of the sensor to the diagnostic mode.

Key research results are as follows:

- Recommendations for the instrumental analysis of the technical condition of hydraulic structures have been developed.
- An automation concept for the water resource control and use as well as mechanisms for the complex modernization of hydraulic complexes have been developed.
- The DUV device has been developed that meets the requirements of modern automated systems and means for monitoring water resources. It was tested in the Bazarbay canal of the Talas hydraulic complex.

Key research results for 2016 are as follows:

- New software has been developed for the implementation of the DUV 2/0,005-5.
- An imitation model of the distribution of water resources of transboundary rivers was developed according to the basin principle, taking into account the existing agreements on water sharing, water availability forecast, quantitative and qualitative indicators of water resources.
- In order to ensure the normal functioning of the software, a technology of automated water resource control was developed with the expansion of functions and verification of a prototype water level sensor.
- Recommendations on the use of DUV-2/0,005-5 at gauging stations with different canal sections including the testing of gate control flow diagrams during the water distribution interaction in the 1, 2, and 3-level canals were developed.
- Inspection of a technical and operational condition of water metering systems in the South Kazakhstan region was conducted.

- Inspection of a technical and operational condition of water metering systems in the Jambyl region was conducted.
- Inspection of a technical and operational condition of water metering systems in the Kyzylorda region was conducted.
- Inspection of a technical and operational condition of water metering systems in the Aktobe region was conducted.
- Inspection of a technical and operational condition of water metering systems in the Almaty region was conducted.
- Inspection of a technical and operational condition of water metering systems in the East Kazakhstan region was conducted.

Based on the task set, the water management system monitoring was conducted at the following water facilities of the Jambyl region of the Republic of Kazakhstan. The Terisaşçıbulaq reservoir (Figure 1) is a channel reservoir of seasonal regulation.

Over a long period of operation, the instrumentation system has been largely lost at the reservoir. The instrumentation system has not been updated for more than 40 years and the installed instruments have failed due to the expiration of the service life guaranteed by the manufacturer. The current instrumentation system is catastrophically not sufficient for assessing the state of hydraulic structures and foundation.

The Terisaşçıbulaq hydraulic complex has no other measuring instruments.

Figure 1. Upper and lower canal pounds of the Terisaşçıbulaq reservoir.

In order to achieve the goal of implementing new technology, a cycle of constructive developments was carried out:

1) Technical adjustment of the device for setting up and managing information about the operation of the device:

- Implementation of the function to detect the state of GPRS (Internet) connection.
- Implementation of the function to detect the level of GSM signal.
- Implementation of the function to detect the state of connection with the server.
- Implementation of the function to display IMEI code.
- Implementation of the function to display the current account balance.
- Implementation of the function to detect the level of battery charge.

2) Processing commands coming from the server for the configuration, control, and improvement of the data exchange mechanisms between the sensor and the server:

- Implementation of the function to read commands coming from the server.
- Implementation of the function to send the result of the command to the server.
- Insertion of a backup data storage device (a microSD) into the sensor.
- Implementation of the function to read measured values from a microSD.

3) Initialization of the device.

4) Registration of the sensor in the system.

5) Automatic transition of the sensor to the diagnostic mode.

The implementation of the technology of automated water resource metering and control was conducted at the Asa hydraulic complex, the Tasotkel and Terisaşçıbulaq reservoirs (Figure 2).

Figure 2. The implementation of the technology of automated water resource metering and control at the Asa hydraulic complex, the Tasotkel and Terisaşçıbulaq reservoirs.

During the implementation of the water level sensor DUV 2/0,005-5, no equipment or sensor software failure was noticed. The implementation of the DUV 2/0,005-5 into the system of automated water management facilities made it possible to implement fully the uninterrupted supply of planned water volumes to the consumer.

In accordance with the requirements of modern legal and regulatory documents, the existing standardized measurement methods are used to measure discharge and streamflow.

Direct methods such as mass, volumetric and volumetric-hydraulic ones require large expenditures of funds; therefore, they are used mainly in the calibration of working measuring instruments provided for by the metrological support norms (Main river basins, n.d.).

At open irrigation networks' canals, indirect methods of determining discharge are used, which are divided into the following groups.

Direct measurement methods are used when conducting metrological tests, graduation and certification of flow meters and other special equipment. In operational hydrometry, two methods are most widely used - channel and hydraulic ones.

The channel method does not require the construction of special structures. In fixed channels, where there is no influence of backpressure and pressure drop, as well as on stable sections of channels, this method ensures acceptable accuracy of water metering.

The hydraulic method is based on the installation of hydrometric facilities or devices at the corresponding points of IN that allow the measured water flow to pass through them and ensure discharge measurement.

A complex of hydrometric facilities has been developed to use indirect methods for measuring discharge in open channels of existing IN. Hydrometric facilities are typified depending on the methods of measuring water flow parameters (Kolodyazhny, 1990; SNiP 2.06.03-85, 1989; Frumkin & Rubichev, 1987; GPRS, 2015). The distinguishing characteristic of such a typification is the introduction of a new category of hydrometric structures, i.e. “flow converter”.

The current state of water metering and water measuring at agricultural water management systems in recent years is characterized by a significant decrease in the number and level of technical condition of water metering points. The current state of operational hydrometry and its metrological support is critical. In fact, the entire hydrometric network, especially in open channels and structures, does not meet the regulatory and metrological requirements. The instrumental fleet that existed before was practically lost due to the moral and physical wear and tear of measuring instruments, their failure for various operational reasons, lack of maintenance, repair, and metrological calibration.

The analysis of a number of technological developments of past years showed that a large number of tools and devices appeared on the market of measuring instruments. They can be used to modernize information support of existing irrigation systems and, above all, water metering systems.

For comparison, let us take as an example the water level sensor DUV 2/0,005-5 (Kazakhstan), the ultrasonic liquid level meter INNOLevelECHOIL-EC-A (Russia) and Siemens Sitrans Probe LU (Germany).

The development of the software for the information exchange between the control complexes of the lower and upper hierarchical levels of the communication network is the data transfer between the central dispatch console and the automation endpoints. In the case under consideration, the lower hierarchical level is the water level sensors, and the upper level is the central dispatch console and server (duv2.kz).

Alarm system.

The developed program is equipped with an alarm system to notify the personnel about an emergency. This system provides the following functions:

1. Siren sound alarm.
2. Voice alarm annunciators (annunciators can be installed at any distance from the alarm center).
3. SMS Alarm Notification.
4. Voice call alarm.
5. Alarm pop-ups on the dispatcher's computer.

The local alarm system is intended for a narrow circle of people directly involved in the zone of maximum impact of a natural disaster. This system works without access to the Internet.

The global warning system is intended for a wide range of people via Internet communication channels. These include SMS sending, voice calls and notification via voice alarm annunciators located at a considerable distance from the signal source. The Internet is required for this system.

The alarm center should be located in the hydraulic complex endowed with special alarm equipment such as sirens, loudspeakers, GSM modems (sending SMS and voice calls), a computer (dispatch console, sending e-mails).

Sluice gate control.

The developed program enables controlling the gates endowed with an electric actuator.

For remote control, the gate electric actuator must be equipped with a special device for receiving commands from the control system.

The electric actuator control cabinet of the separately standing gates is installed in the immediate vicinity of them.

The control cabinet of the water intake complexes is equipped with buttons for the gate manual control (Figure 3).

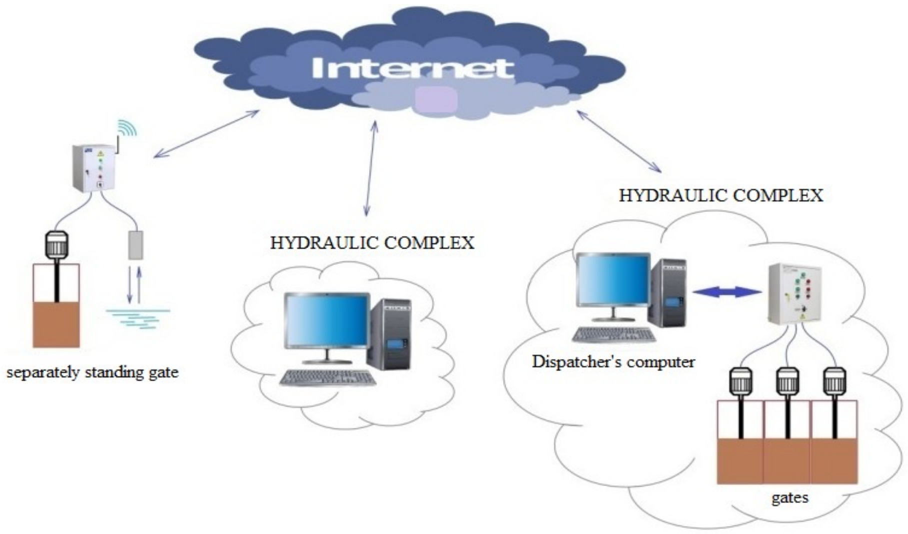

Figure 3. Model of development of cognitive interest of students through the use of information and communication technologies.

The developed system serves both for local control of the gates by the dispatcher (using a computer) and for remote control (control commands will be received via the Internet).

To coordinate the actions of controlling the gates, each hydraulic complex endowed with the necessary equipment is registered in the information collection and processing system.

In order to avoid unacceptable (illogical) actions related to gate control, control commands are confirmed by the dispatcher at the local level.

The information exchange between sensors and the central server is carried out through cellular communication channels by connecting to the Internet via GPRS.

Each sensor sends an HTTP request to the Internet via the duv2.kz server. The request transmits the measured data, the sensor's identification number and measurement time, as well as some additional information about the state of the sensor's operation, errors, etc.

The server receives and stores the information transmitted from the sensors in the database. This information is provided to the user upon request in the form of various graphs, reports, etc. The accumulated information can be saved as an Excel file.

Figure 4 presents a map with a display of sensors located there and measured (level in mm) and calculated (level in m3/h) data (Klyuchevsky, 2010). Each registered user will see such a map in the duv2.kz system.

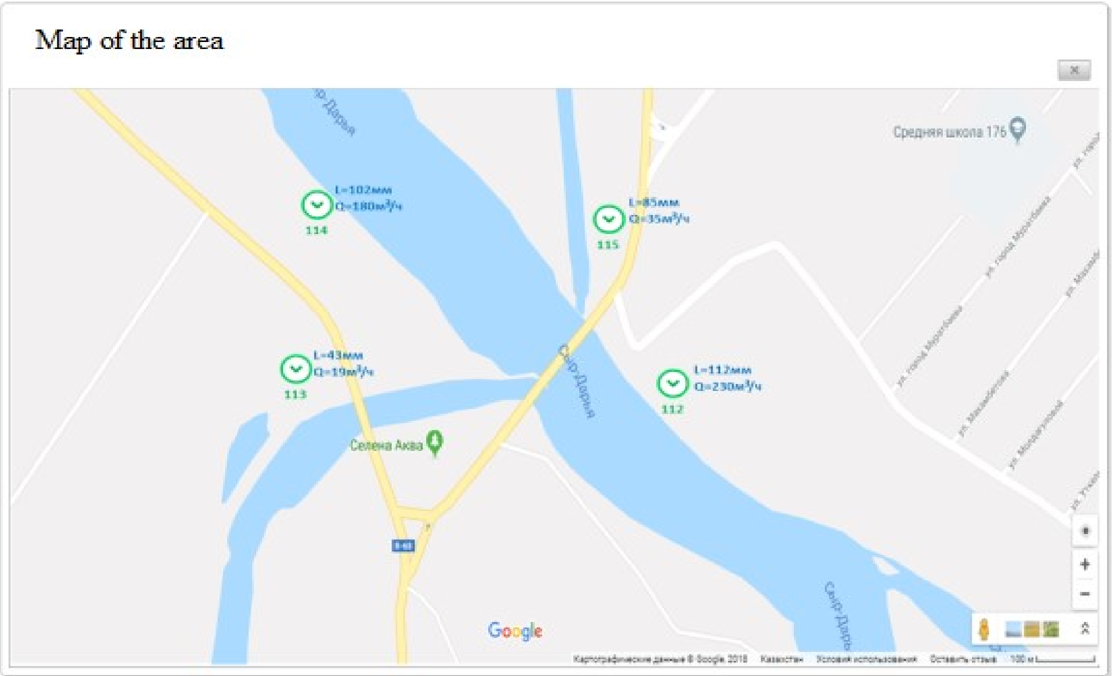

Figure 4. An example of a map of the area with the display of several level sensors and their readings.

Geographical coordinates are entered for each sensor separately when registering in the system, or later when editing sensor properties. These coordinates are determined by the user himself/herself, using the mobile application, being in close proximity to the sensor.

Communication network data transmission system.

As for the security of transmitted information, it is transferred openly without encryption. Of course, this is not very good in terms of the reliability of the information received. In order to ensure the security of information transfer, it was decided to enable the authorization system for each sensor by entering login and password. Now each sensor is identified by the IMEI code.

A data encryption system was also applied. The data sent via the GPRS channel cannot be protected but encrypted messages can be sent and then decrypted on the server.

Water level sensors are equipped with GSM modems that can be connected to the server (duv2.kz) using GPRS communication channels provided by cellular operators (GPRS, 2015) (Figure 5).

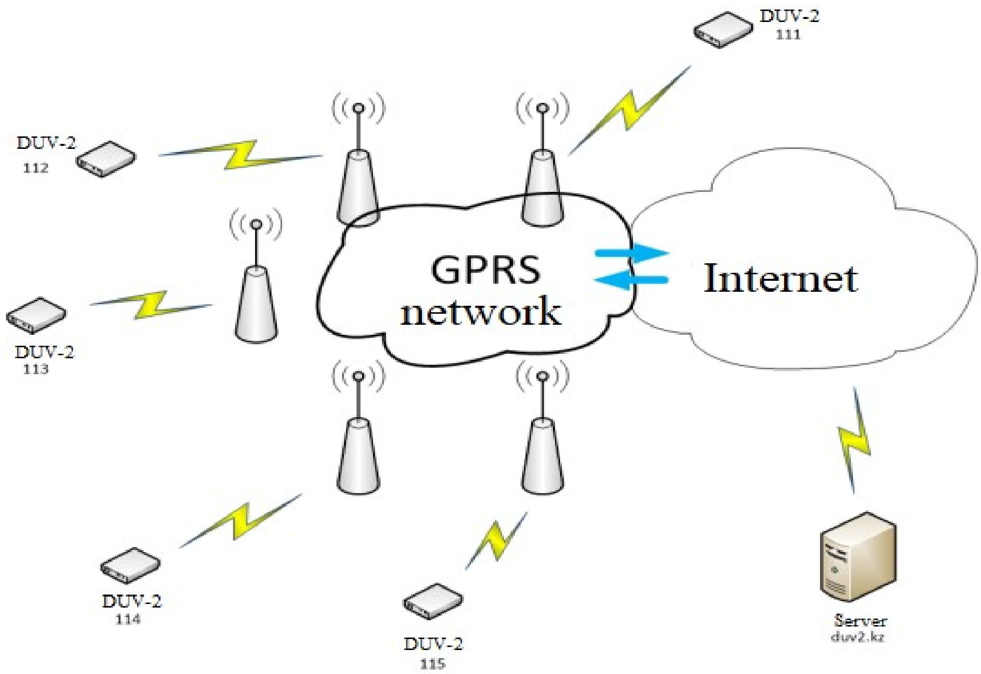

Figure 5. Communication network's structure.

The sensor performs an HttpGet request to the duv2.kz server. At the same time, all data transmitted from the sensor are transferred openly in the URL string (Figure 6).

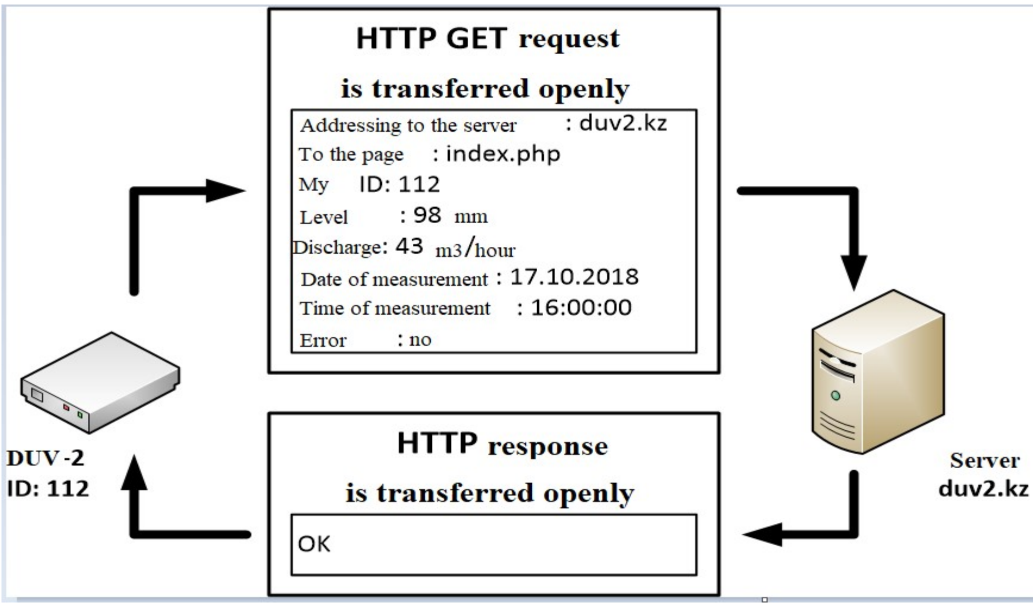

Figure 6. Http Get request structure.

In order to hide the transmitted data from prying eyes, the sensor needs to be able to perform HTTP POST requests to the server (Chengayev, 2015) (Figure 7).

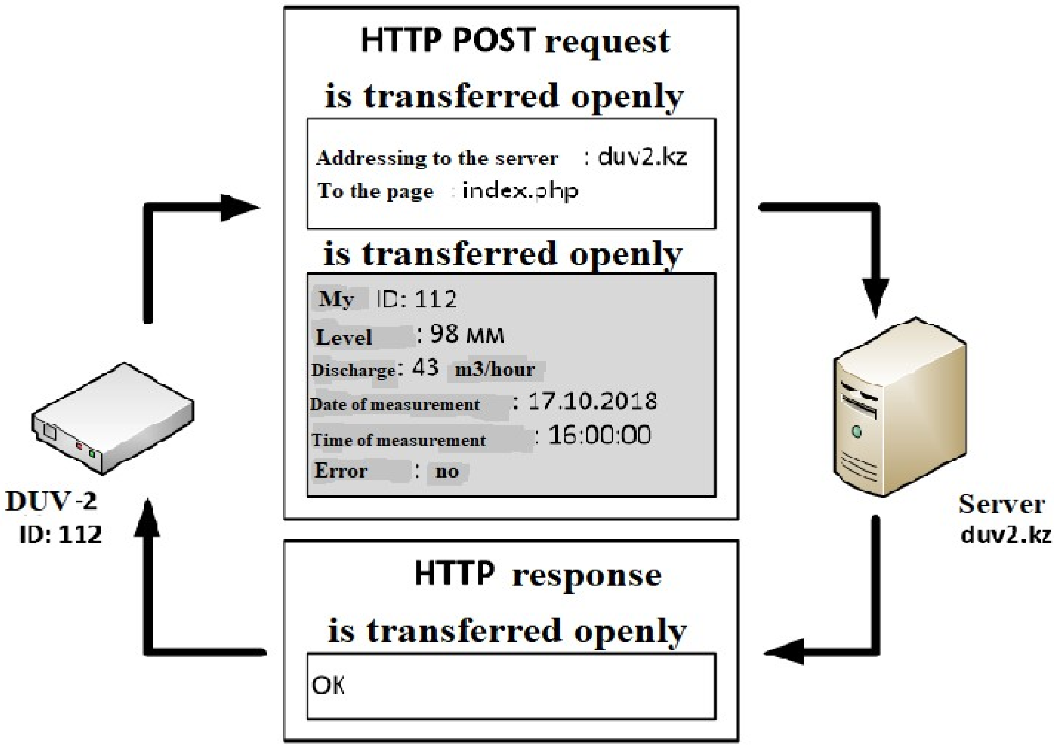

Figure 7. HTTP POST request structure.

This will hide the information from prying eyes but not from "hackers" who can track the transmitted information. It is not easy to do this on GPRS networks, so transferring data via an HTTP POST request is much safer.

Sensor authorization by entering login and password.

The authorization is applied in order to strengthen the protection of data from "outsiders." Usually, users who register on Internet sites need authorization. The user must enter a username and password to get to his/her personal page (personal account).

Water level sensors, as well as users, also use the duv2.kz site and are connected to it to give their measured data. Unlike a user, the DUV-2 sensor has no separate authorization. Data from the sensor are added to the database using a normal GET request. Therefore, if an “intruder” wants to enter deliberately false information into the database, all he/she has to do is type the necessary URL in the browser and perform a GET request from his/her computer.

In order to avoid such consequences, it is necessary to force the sensor to be identified by the system. This can be done immediately in a POST request by passing the values of the “user” and “password” fields (Figure 8). The value of the password field is transmitted in encrypted form.

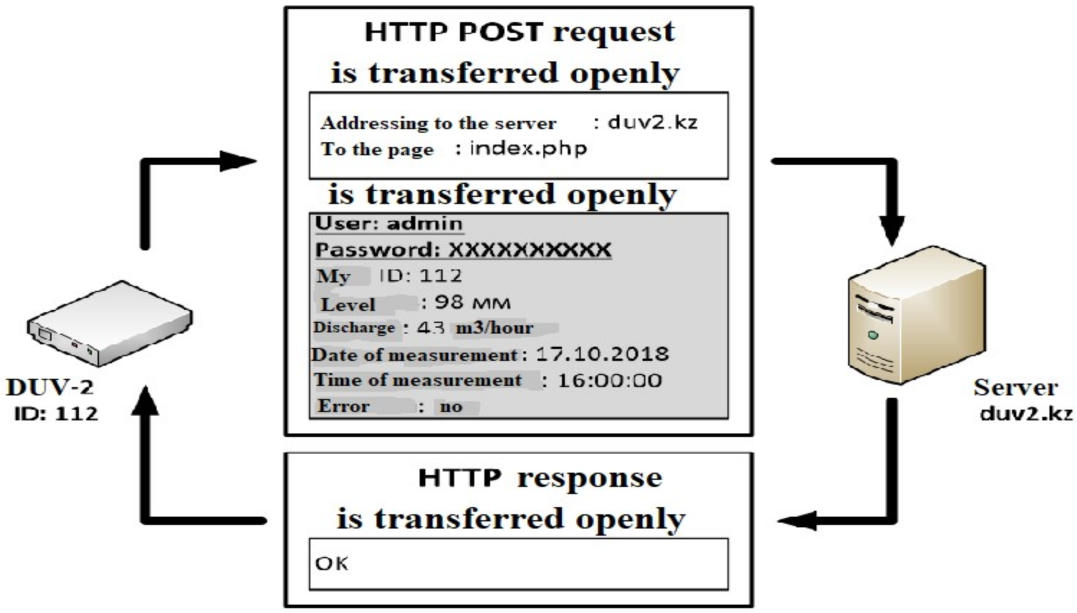

Figure 8. HTTP POST request with additional authorization fields.

Accordingly, without knowing the login and password, the "intruder" will not be able to enter deliberately false information in the database.

The logins and passwords of the sensors do not have to be different. For example, for one user, all registered sensors will have the same login and password (as a rule, the login, and password of the user).

Encryption system of transmitted data packets.

In order to ensure complete protection of the transmitted data, they need to be encrypted. There are many different encryption systems (Maiwald, 2001). All of them have advantages and disadvantages. If using a well-known encryption system, then sooner or later it will be decrypted, and the data will be "hacked." Therefore, it is necessary to use a variable key encryption system.

Each encryption system has two components:

1. Key (it must be known only to participants of the transmission).
2. Encrypted message (transferred openly).

In the case under consideration, the sensor, because it first accesses the server, must select a key that the server knows, and encrypt its request. Then the sensor sends it to the server via the available data channels.

After receiving the request, the server extracts the encrypted message from it and tries to decrypt it with the keys it has.

Keys can be selected from the list depending on time. Figure 9 shows how keys are selected depending on time.

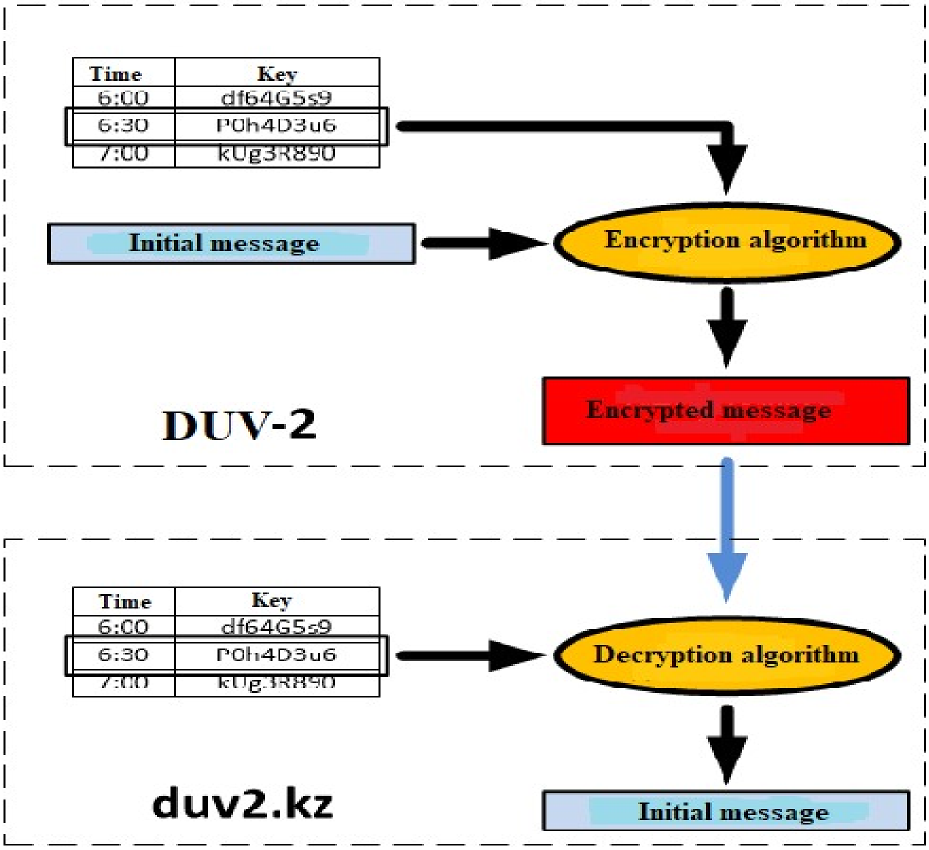

Figure 9. Selection of encryption key depending on the time.

In this case, the key tables in the sensor and on the duv2.kz server have to be identical. In addition, these tables can change after a certain time interval.

When forming the response, the server also encrypts the message with the same key and sends it to the sensor. When accepting the response, the sensor decrypts the message and performs the required actions.

The water level sensor DUV 2/0,005-5 enables expanding the spectrum of technical assistance to measure water levels on irrigation networks by creating a utility model that is fairly simple in design, affordable and has acceptable operational properties (Figure 10) (Imanaliyev, Balgabayev, Karlykhanov, Li, Bakbergenov, & Tazhiyeva, 2018).

Figure 10. Water level sensor DUV 2/0,005-10.

The device uses an ultrasonic sensor that determines the distance between the sensor surface and the water surface.

The DUV 2/0,005-5 device records the water level at the gauging station after a certain period of time, recalculates it in terms of discharge according to the curve Q = f (H) of the program incorporated in the device.

The review of modern technologies and general-purpose measuring instruments was aimed at developing certain technical requirements and practical recommendations for their wide application in agricultural water management facilities. Table 1 shows the comparative characteristics of water level sensors from various manufacturers.

The DUV 2/0,005-5 device operates in two modes: test and working ones. In test mode, the measurements do not start on schedule. The DUV 2/0,005-5 device is constantly waiting for commands entered from the serial port, and every 30 seconds there is a check of new SMS and new server commands. In this mode, it is possible to set up the DUV 2/0,005-5 device, view saved settings, check whether data is being sent, check balance, etc. In the test mode, the GSM modem is constantly on, registered in the GSM network and connected to the Internet via GPRS.

Prior to the beginning of the growing season, the sensors are mounted at gauging stations after preliminary preparatory work. In technical terms, the installation works represent the installation of the device on the surface of a stilling well inside a metal box with a size of 30x30x30 mm rigidly fixed to the transversing angles of the well (Figure 11). The distance between the surface of the well and the maximum water level in the well has to be at least 0.5 m (Siberian State Road Transport Academy, 2008; Main river basins, n.d.).

Figure 11. Installation of the DUV 2/0,005-10 device on the surface of the stilling well.

The implementation of the DUV 2/0,005-5 devices at gauging stations of irrigation systems will lead to an increase in the accuracy of determining the water level, discharge and the speed with which information is obtained in comparison with known methods. The use of this device in the context of water resources shortage will enable, on the one hand, a just water use metering, and the water saving by users, which will lead to an increase in the technological development of the agroindustry and labor productivity.

At the moment, the DUV 2/0,005-5 device is undergoing the registration procedure in KazInMetr and the water level sensor type-approval procedure in the registry of the State system for ensuring uniformity of measurements of Kazakhstan.

CONCLUSIONS.

As conclusions:

1. Water facilities and automation systems at Kyzylorda, Talas and Sayramsu hydraulic complex were examined and the automation degree of water metering and management. The database on technologies of automated water management in river basins in the world and in Kazakhstan has been replenished and systematized.

2. Recommendations have been developed for providing instrumental analysis of the technical condition of hydraulic structures. They can be taken into account when inspecting hydraulic structures during operational monitoring of their state, during commission inspections when preparing them for winter, for passing freshets and during after-freshet inspections. In these cases, the research results may be included in annual reports and statements on the status of hydraulic structures.

3. A concept was developed for water resource management and use automation with the development of mechanisms for the comprehensive modernization of hydraulic complexes. The introduction of the main provisions of the concept into practice should lead to a reduction in water losses through clear coordination of water management actions.

4. The DUV device meeting the requirements for modern automated systems and water resource monitoring equipment has been developed. It was tested in the Bazarbay canal of the Talas hydraulic complex. The sensor stores the data and transmits them to the LAN system at the user's

request. All the calculations are performed in the LAN system and their results are sent to the server with the user's webpage, which reduces power consumption and increases the reliability of the sensor. In the future, it is planned to include the DUV device in the state register, which will enable implementing the water metering automation at gauging stations.

5. A scheme has been developed for the modernization and reconstruction of hydraulic complexes taking into account the water metering and distribution automation. This scheme provides for ways to develop water resource monitoring automation systems in the future.

6. Considered information systems provide for the collection, storage, processing and retrieval of information. It is possible to conduct a qualitative analysis of problems and make measured decisions with the help of information systems. Information systems can significantly improve the efficiency, productivity, and quality of work while reducing costs. Reliable information is delivered to the user in a timely manner, while access to information can be obtained from anywhere in the world, without being tied to a specific place of work.

7. The examination of the technical and operational condition of the water metering systems in the Jambyl, Turkestan and Kyzylorda regions of Kazakhstan showed that water flow automated measurement systems are under-equipped.

8. The existing irrigation systems in the Republic of Kazakhstan practically have no digitalization system for the water metering control. This is explained by the fact that the irrigation systems built in the 60–70s of the last century were designed for manual control of facilities. The translation of such systems to automated control is fraught with certain difficulties associated with a large ramification of control objects, the inertia of transient processes, the action of a large number of random factors affecting crop formation, as well as the lack of research and regulatory information.

9. The results of the creation of the modernized model of water resource management automation in terms of both hardware and software showed the promise of research in this area. The modernized

model has a higher quality of work, functionality, and versatility, the ability to compete on the market of similar devices in the field of water management.

10. The developed software made it possible to organize better the data exchange between control complexes of the lower and upper levels. Now it is possible to track sensors on the map. The built-in alarm system enables a prompt notification of the personnel about emergencies and system malfunctions, to make appropriate decisions. The implemented gate control system enables an efficient water resource distribution according to the water consumption schedule as well as during emergencies. Transmitted data are protected from unauthorized access. The possibility of substitution or entering of deliberately false readings no longer exists.

11. The software has been developed for the implementation of the DUV 2/0,005-10 device. This software solves the problem of processing experimental data of the water level at hydraulic complexes. The software includes data processing, data transmission system diagnostics, data transfer modem setup, data transmission system error diagnostics, real-time query system, software diagnostics, software error diagnostics, measuring sensor system diagnostics, charge monitoring system, ultrasonic water level sensor adjustment.

12. An imitation model of the water resource distribution of transboundary rivers was developed according to the basin principle, taking into account the existing agreements on water sharing, water availability forecast, quantitative and qualitative indicators of water resources. As a result of water distribution modeling in the Bazarbay main canal, during the entire vegetative period, discharges at each water outlet were revealed. These discharges are the initial value for decision-making (at the level of administrative bodies) for changing or reducing irrigation areas on one or another site for a low-water year with a deficit of average annual water consumption.

13. To ensure the normal functioning of the software, the technology of water resource automated control has been developed with the expansion of functions and testing a prototype water level sensor.

14. The tests carried out with the DUV 2/0,005-10 device at the Asa hydraulic complex, the Terisaşçıbulaq reservoir and Bazarbay canal confirmed the device's performance under actual operating conditions. According to the results of the sensor and stream gauge readings, the measurement error does not exceed 5%.

15. Recommendations on the use of the DUV 2/0,005-10 device at gauging stations with different canal sections and testing (working out) process flow diagram for gate control were developed. These diagrams imply the water sharing interaction on the channels of the 1st, 2nd and 3rd levels, which allow to lay down progressive water metering technologies taking into account the parameters of flow and channel and optimize water distribution in the zone of different level channels.

16. The examination of the technical and operational condition of water metering systems in the regions of Kazakhstan showed that water flow automated measurement systems are under-equipped. The current state of operational hydrometry and its metrological support are critical. Almost the entire hydrometric network, especially in open channels and structures, does not meet regulatory and metrological requirements. The existing instrumental fleet has become obsolete due to moral and physical wear and tear.

17. All of the above works have enabled a significant improvement in the technical and operational characteristics of the water-metering device.

18. Technology has been developed for the implementation of the automated water metering and management system at the Asa, Tasotkel and Terisaşçıbulaq hydraulic complexes in the Jambyl region. A cycle of constructive developments was carried out to achieve this objective.

19. Measures to improve the sensor performance were taken. In particular, the fine-tuning of the device for setting up and managing information about the operation of the water metering device was made:

GPRS (Internet) connection status.

GSM signal level, server connection status.

IMEI code, current account balance, battery charge.

Processing configuration and control commands coming from the server to improve the data exchange mechanism between the sensor and the server.

Insertion of a backup data storage device (a microSD) into the sensor.

Improvement of the sensor performance with the initial settings, i.e. initialization.

Registration of the sensor in the system and automatic transition of the sensor to the diagnostic mode.

20. Recommendations were developed for improving the automated water metering and management system in the south of Kazakhstan. The developed recommendations can be used by operational water management organizations, as well as by standardization and metrology bodies during calibration and examination of water metering devices.

21. The monitoring of the water resource management system at the hydraulic complexes in the regions of the Republic of Kazakhstan was conducted. It showed that the irrigation networks of the Republic of Kazakhstan actually lack measurement tools for agricultural water management purposes fully meeting modern technical and metrological requirements.

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