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Development of a PID controller for an automatic water purification system

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ABSTRACT: The high salinity of water negatively affects soil fertility up to yield loss. In regions with high salinity, unorthodox methods and devices are used to lower the level of mineralization. This article discusses the use of an automatic decision-making system for a device to lower the level of mineralization by diffusion mixing. Construction able to filter water to irrigation rates up to 3 grams per liter and extent the operating period of reverse osmosis. This article addresses the issue of retention of indicated volumetric salinity of the structure using a PID controller. The article presents a diagram of technical implementation and a program developed for the controller in order to implement an automatic water purification system for irrigation.

KEYWORDS: Automation, Irrigation, Water salinity, Water treatment, Programming, PID regulation.

I. INTRODUCTION

The primary aim of irrigation is to provide a crop with adequate and timely amounts of water, thus avoiding yield loss caused by extended periods of water stress during stages of crop growth that are sensitive to water shortages. However, during repeated irrigations, the salts in the irrigation water can accumulate in the soil, reducing water available to the crop and hastening the onset of a water shortage. Understanding how this occurs will help suggest ways to counter the effect and reduce the probability of a loss in yield [1].

Desalinated water is being used for irrigation purposes in many places around the world, where the available water source is too saline to be used. Such water sources may include groundwater, sea water and sometimes surface water from lakes [2]. Water salinity is a major problem for agriculture. Saline water contains high concentrations of salts, which crops might not tolerate. The source of the salts in water is the surrounding rocks, e.g. the mineralogy of the aquifer. Therefore, surface water is usually less salty than groundwater, which is surrounded by rocks. Oceans are salty because when water evaporates, the salts remain and accumulate [3].

Groundwater may contain high concentrations of ions such as sodium, chlorides, sulphate, bicarbonates, calcium, and magnesium. It may also contain trace elements such as boron, iron, manganese and fluoride, which may be present at relatively low concentrations, but might become toxic to the plant if their concentrations exceed certain thresholds (such thresholds are usually crop-specific)[4].

Soil salinity is a term that includes saline, sodium and alkaline soils, respectively defined as (a) high salt concentration, (b) high sodium cation (Na +) concentration, and (c) high pH often due to high CO_3^2 concentration - in the soil. Salinization of soils leads to a change or even disruption of the natural biological, biochemical, hydrological and erosion Cycles of the Earth. Thus, high levels of salinity can lead to the loss of emerging soil resources, goods and services that affect agricultural production and environmental health, which will eventually develop into a sociocultural and human health problem that impedes economic and general well-being [14].

Desalination is a water treatment process in which salts are removed from water. There are various methods of desalination, of which, the main method used today is Reverse Osmosis.

In reverse osmosis, water is pushed through semi-permeable membranes, using pressure. The salts do not pass through the membrane, while water molecules do.

In Uzbekistan, the economic and demographic burden on land, especially for agricultural purposes, is increasing from year to year. Of the 17.8 million hectares representing the total agricultural land in the republic, only 25% is arable land [5]. Over the past 15 years, the area of agricultural land has decreased by more than 5%, and per capita - by 22% [6].

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Over the past 30 years, the area of irrigated land per capita has decreased by about 25%, i.e. from 0.23 ha to 0.16 ha. Naturally, the above data indicate that farmers are reduced to flat out for work, and thereby their incomes are also mourned. The process of anthropogenic desertification, that is, associated with human activity. Soil erosion and soil salinization processes are continuing. Over 3 million hectares of land suffer from wind and water erosion - for the season the average loss of the fertile layer, for this reason, reaches 80 tons per hectare[7].

To eliminate this kind of problem, different methods and devices are used to reduce the salt content of water, one of which is diffusion mixing devices. This type of lowering the salinity of the water is interesting in that it is portable.

But it is worth noting that it requires local management, which does not make it possible to use it for large areas of land with small working personnel.

II. LITERATURE SURVEY

The control algorithms of the automatic system implementing based on the logic loaded into the controller then receive accounting data about the ongoing technological process using measurement modules and sensors.

The technical side of the implementation of an automatic system based on the integration of modules, sensors, actuators, and a programmable logic controller.

The design that use for water treatment has its own specific character and requires an individual approach to the development of an automatic control system. An automatic technical system cannot realized without a printed circuit board and integration connection. This article discusses the development of PID controller for design of selective selection of the volume of water for filtration. Similar issues of creating a topology for the same technological processes were discussed in the works of such scientists as Senpinar A., K. Arnold, P. Srihari, J. Dilella.[8]

III. MATERIALS AND METHODS

A. OBJECT OF RESEARCH

The object of research is construction for the selective choice of purification or direct supply of water to the mixing capsule.

The basic principle of operation of the proposed design is to create the required concentration of water with an acceptable salt content inside the tank and then transfer it for irrigation.

The device consists of 5 parts; 1- conduct metric sensor that will be installed in the water source to determine the salt content in the source, 2- centrifugal pump for water transfer, 3- on-off solenoid valves for water distribution, 4- reverse osmosis to lower the salt level in the water, 5- capsules for collecting water (see Figure 1) [9].

The principle of operation of the construction is that the electromagnetic control valve $V`_1$ distributes water for cleaning using reverse osmosis, valve $V`_2$ is used to supply purified water to the capsule, valve $V`_3$ is used to supply mixed water for irrigation. The valve operating time and the volume of water flow distribution for cleaning and for direct transfer to the capsule depending on the salinity of the water source. The data that is transmitted from the 1st sensor goes to the controller, and after that the controller, based on the built-in algorithm, sets the operating time of the on-off valves. The level of reverse osmosis load depends on the salinity of the water source and thus it is possible to extend the level of operation of the reverse osmosis by creating an individual regime depending on the degree of salinity of the water.

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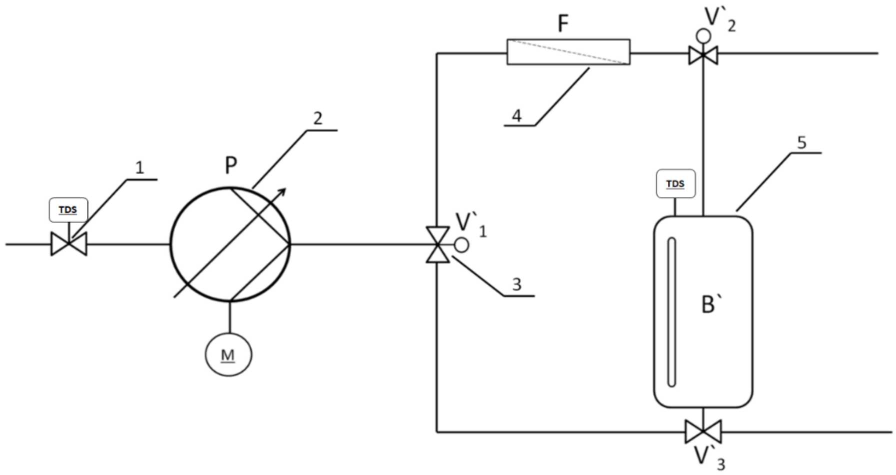

1-conductivity sensor; 2-pump unit; 3- two position solenoid valve; 4- reverse osmosis;
5- tank of diffusion mixer.

Figure 1. Scheme of construction of diffusion mixing system.

The main work of liquid separation is carried out by means of distribution by a two-position valve in a certain time interval. The interval and duration of the valves depends on the performance of the source sensors and the capsule of the diffusion mixing[9].

B . ALGORITHM AND METHOD OF CONTROL

All this work will control by automation system which make set autonomy work. All work will base on decisions making system on base of program for Atmega 328 microprocessor.

Algorithm of work this system base on the equation-1 composition of the source water from the first sensor is known, and the required final concentration of irrigation water to be obtained is known. It is required to obtain it by adding pure water from a filter to the initial saltwater containing the required substance. According to the formula below, we can get the amount of pure water needed for the initial part.

$$V_2 = \frac{C_1 V_1 - C V_1}{C - C_2} \qquad (1)$$

In (1) The concentration of the substance in the first component of the mixture C_1, the volume of the first component of the mixture V_1, the concentration of the substance in the second component of the mixture C_2, the final, the required concentration of the substance C[10].

For the technical implementation of the above equation use PID regulation law with form wich shown in (2) equation. Based on the equation, information from the sensors is received, it is analyzed and, during the continuous mixing process, it corrects the volume of salt content inside the capsule.

$$o(t) = P + I + D = Kp\, e(t) + Ki \int e(t)dt + Kd\, de(t)/dt \qquad (2)$$

o (t) - output signal;
P - proportional component;
I - integrating component;
D is the differentiating component;
Kp, Ki, Kd - coefficients of proportional, integrating, differentiating links;
e (t) - mismatch error.

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The technical implementation of this equation is carried out as follows switching on and off of two-position valves is described on the basis of scheme number two. Confirming the level of the content above or below the specified norm the water components transfers it for filtration or directly in diffusion mixing capsules (see figure 2).

The algorithm of the technological process, and its automation is carried out in this way, at the beginning of the process, the initial data from the sensors is taken initially, and then they are compared using equation 1, if the water level exceeds this standard for irrigation, which is 3 g per liter, then the water is sent for cleaning. to say that the total volume in the distribution of water is precisely the proportion inside the capsule based on the salt content inside the source. The main logic of the system is to bring the content inside the capsule up to 3 grams, regardless of the volume of salt content inside the source, if the salt content inside the source is high, then the operating time of reverse osmosis increases significantly and the distribution valve mainly operates in the purification mode (see figure 3) [11].

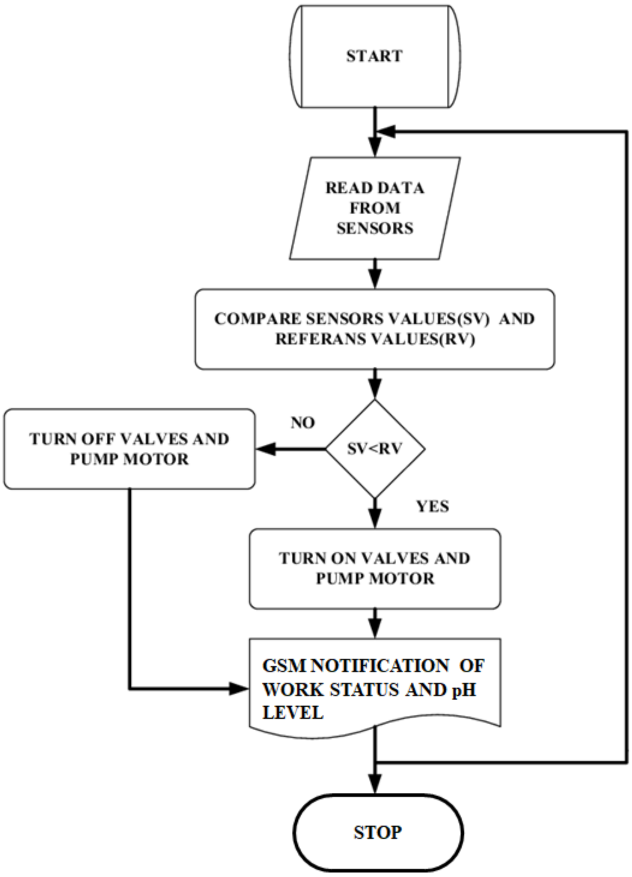

Figure 2. Block scheme of decision making system

The block diagram of the PID voltage regulator looks like this (see figure 3).

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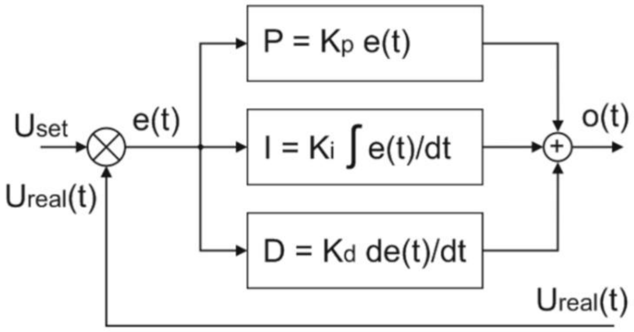

Figure .3. Diagram of the control system algorithm

The measured voltage Ureal (t) is subtracted from the specified Uset.

The resulting mismatch error e (t) is fed to the proportional, integrating and differentiating links.

As a result of the sum of the components, a control action o (t) is obtained, which is fed to the regulating element [12].

IV. RESULTS AND DISCUSSIONS.

Implementation of an automatic system for the controller, a program was created based on the above algorithm and block diagram on the Arduino IDE platform. The following sketch was developed to mix two different liquids with different contents.

```
int setpoint = 0; // set value that the regulator must maintain
int input = 0; // signal from the sensor (for example, the temperature that we regulate)
int output = 0; // output from the regulator to the control device (for example, the PWM value or the angle of rotation of the servo)
int pidMin = 0; // minimum output from the regulator
int pidMax = 255; // maximum output from the regulator
// coefficients
float Kp = 1.0;
float Ki = 1.0;
float Kd = 1.0;
float _dt_s = 0.1; // iteration time in seconds
// auxiliary variables
int prevInput = 0;
float integral = 0.0;
// PID
// function for calculating the output signal
int computePID () {
  float error = setpoint - input; // regulation error
  float delta_input = prevInput - input; // change the input signal
  prevInput = input;
  output = 0;
  output + = (float) error * Kp; // proportional to the regulation error
  output + = (float) delta_input * Kd / _dt_s; // differential component
  integral + = (float) error * Ki * _dt_s; // calculating the integral component
```

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```
        // here you can limit the integral component!
        output + = integral; // add integral component
        output = constrain (output, pidMin, pidMax); // limit the output
        return output;
}
```

Based on the above data, a batch mixing prototype of Figure -3 was constructed. The volume of the capsule for mixing is 300 ml. TDS sensor is used to determine the salt content of the source and the mixing capsule. Considering the fact that the water concentration is based on the volume and operating time of the valves, an electrode type water level sensor was installed in the inner part of the capsule, can been (see figure 4)[13].

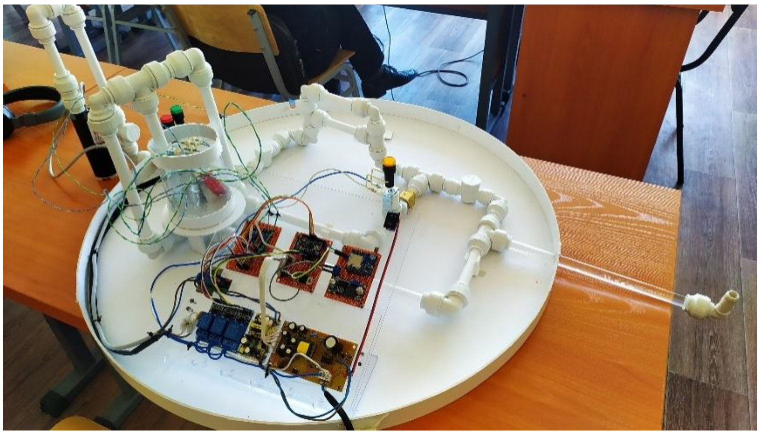

Figure 4.experemental prototype

This experimental construction was created on the basis of the aforementioned schematic diagram of figure 1.

Solenoid manifolds DN10 SM88632 are used to control the water flow. The volume of water for filtration depends on the salinity of the water, the opening and closing times of the valve are determined according to salinity of water in source.

During the experiment, the ratio of the valve operation time for filtration with the volume of salt in water was determined, which are presented in table-1 .

Table 1. Parameters of work solenoid manifolds according to salt value

Water classification	Total dissolved solids	Opening time of valve $v`_1$ to filter
Brackish water:	10,000 mg/L	*25 seconds*
Saline water:	35,000 mg/L	*45 seconds*
Hypersaline	45,000 mg/L	*60 seconds*

A process control board has been designed on the architecture which shown on fig.3. When the device is working, it shows that 0.98 grams of salt are in the liquid, which is the normative indicator for irrigation.[14]

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V. CONCLUSIONS

1. To carry out the cleaning process in this structure, the place of water accumulation must be predetermined. Valve run times are based on the total tank volume and the salinity of the water.If the salinity of the water is more than 45 grams per liter, then the operation of the system will be 100% based only on the work of reverse osmosis.
2. As feedback, a second TDS sensor inside the capsule used for notifies about the quality of the mixed water using the terminated GSM module. This variation of the feedback makes it possible to make monitoring remotely if it was illuminated to select the appropriate operation for the device to work.
3. The construction gives the possibility to the exploitation efficiency of the reverse osmosis filter increases by 13%, which allows farmers to use this technology longer.
4. The volume of untreated water is directly related to the level of salinity of the water.

REFERENCES

[1] Vlotman W.F. 2020 "Present status and future prospects of drainage in relation to the icid vision 2030", Irrigation and Drainage, Vol.69, pp. 218–229,2020.
[2] Ayers R.S. & Westcot, DW. & FAO, Rome & AGL, "Water quality for agriculture", pp.145-149,1985.
[3] Minhas P.S., "Quality of Irrigation Water: Assessment and Management", Agric. Water Managment Vol.1**,** pp.227-228,1992.
[4] Guy S.,"Irrigation with desalinization water", cropaia.com,2019. https://cropaia.com/blog/irrigation-with-desalinated-water/
[5] Phogat V ,"Management of soil salinity associated with irrigation of protected crops",Agriculture Water Managent, Vol.227,pp.237-238,2020.
[6] Charyev R.R, Ismailova A.I, Mirzaev, "Pollution of surface water of the Tashkent region of the Uzbekistan Republic" Gr Bulletin Of Orenburg State University ,Vol.6,pp.78–80, 2017.
[7] Abdurakhmanov M.A., Rakhimov Y.T. The state of land resources in the Republic of Uzbekistan. The territory of science. 2017. No. 4, pp 37-40.
[8] Dubey, Swati & Agarwal, Madhu & Gupta, Akhilendra & Dohare, Rajeev & Upadhyaya, Sushant., "Automation and control of water treatment plant for defluoridation", International Journal of Advanced Technology and Engineering,Vol(4)26,pp.6-11, 2016.
[9] Bharti A. "Phase Equilibria in Ionic Liquid Facilitated Liquid-Liquid Extractions",235-247, 2017.
[10] Senpinar A. "Internet-/Arduino-controlled PV automatic irrigation system for clean environment", Int. J. Environ. Sci. Technol.*Vol.*9, pp. 5185–5196. 2019.
[11] Gazieva, R.,Ozodov, E. "Automatic diffusion mixing system for watering in regions with high water sales",International Conference on Information Science and Communications Technologies: Applications, Trends and Opportunities, 2019.
[12] Gaziyeva R., Ozodov E. Automatic decision-making system for the desalinization of water for irrigation, IOP Conference Series: Earth and Environmental Science.,Vol.614 ,2020.
[13] Gaziyeva R., Ozodov E. "Programming the atmega2560 microcontroller for an Automatic control system of water treatment process in Regions with high salt content", Sustinaible Agriculture, Vol 4(08),pp.30-32.2020.
[14] Liu A, Qu Z, Nachshon U.," On the potential impact of root system size and density on salt distribution in the root zone", Agriculture Water Manag. Vol. 234.,2020.