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Remote monitoring of reagent treatment of recycled water supply systems

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Abstract. A system for remote monitoring of the reagent treatment of the cooling water of a petrochemical enterprise has been developed, manufactured and tested. The system includes a controller in which signals from level sensors in reagent storage tanks, pH sensors and electrical conductivity are collected and processed. The received data is sent to the server, which is accessed from any device with Internet access. The approbation of the remote monitoring system at the petrochemical enterprise made it possible to ensure an uninterrupted supply of reagents and reduce the corrosion rate by 5 times.

1 Introduction

Water, as a technical object, is a difficult to predict liquid, it serves as a universal solvent for organic and inorganic substances, serves as the basis for the life activity of aquatic organisms and, therefore, is difficult to predict the degree of impact on pipelines and equipment of circulating cooling water systems [1].

Reduction of water consumption from rivers and lakes by industrial enterprises leads to a significant increase in salinity in recycled water [2, 3], which leads to the deposition of salts on the internal surfaces of equipment. The use of conditionally treated wastewater from biological treatment plants increases not only the salinity, but also the number of bacteria adapted as a result of long-term breeding to use iron bacteria as a nutrient substrate for corrosive deposits on equipment, hydrocarbons and reagents - heterotrophic bacteria, sulfates – sulfate-reducing bacteria. Bacteria in the circulating system have ideal temperature and chemical conditions for their vital activity and without constant monitoring of their content it is impossible to ensure long-term operation of equipment in contact with water [4-6].

The situation at hydrocarbon separation and production plants at oil refineries changes hourly - the passage of one heat exchanger tube creates conditions for the explosive growth of hydrocarbon–oxidizing heterotrophic bacteria, which form low-molecular organic acids and eventually lead to local corrosion of equipment. A change in the pH of water towards a decrease in values also causes increased corrosion, and an increase in pH leads to a significant increase in salt deposition and a decrease in the efficiency of heat transfer in equipment [7-9].

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The secondary use of wastewater in the form of treated wastewater from the BOS leads to the need for constant accelerated circulation of salt-saturated water through the BOS. Circulation with purification only from hydrocarbons using bacteria increases the salinity and reduces the evaporation coefficient and, ultimately, leads to a decrease in the concentration of reagents based on organic compounds (biocide, corrosion inhibitor and salt deposits, dispersant) in recycled water (with an evaporation coefficient of 1.5, the concentration of the reagent is 2 times less than with the evaporation coefficient 3.0 with constant feed and even lower with shocks.

2 Results and discussion

In order to optimize the supply of reagents and ensure a minimum sufficient dosage, an automated remote monitoring system for the reagent dosing system and the state of recycled water (UMD) was developed.

The UMD system consists of telemetry cabinets, a data collection and transmission server, and a client program for viewing current and archived data. The block diagram of the system is shown in Figure 1.

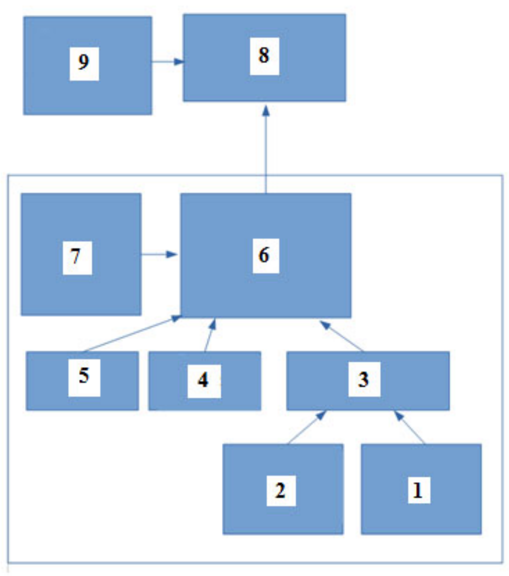


Fig. 1. Block diagram of a smart device with one telemetry cabinet: 1 – pH sensor, 2-conductivity sensor, 3-signal converter, 4, 5-liquid level sensor, 6-controller, 7-power supply, 8-server, 9-client program for viewing and managing data.

Figure 2 shows the appearance of the telemetry cabinet. The telemetry cabinet consists of: 1-a 24V power supply; 2-a SOURCE 432-TM controller, which includes 3-four 4-20 mA inputs and 4-a GSM modem for transmitting telemetry information to the server; 5-two level sensors with 4-20 mA output; 6-an electrical conductivity sensor and 7-The PH sensor, which are connected to the controller via an 8-signal converter to a standard output of 4-20 MA. In addition to the above, the telemetry cabinet includes auxiliary devices: 9-three circuit breakers, 10-terminal blocks for connecting 220V, 11-outlet for connecting the pump, 12-remote GSM antenna.

The Istok-432 TM controller polls the inputs of 4-20 mA, recalculates the current value into the value of a physical quantity in accordance with the specified coefficients and sends this data to the server program 1 time every 12 hours (this period can be programmed).

Using the client program, the user can view the parameters of all the connected objects both in tabular and graphical form. The client program can be installed on any device with the ability to access the Internet. All data is archived and, if necessary, can be read for a selected period of time.

Figure 3 shows the appearance of the data table received from each smart device. In this case, 17 devices are used, of which 16 are in available mode (connected), one is not serviced. Using the "Edit", "Delete", "Add" buttons, you can make changes to the table settings. The upper menu allows you to view "Events" - power outages, UMD communications, individual sensors; in online mode, adjust the settings of the UMD device in the "Connection" menu; view the status of all UMDs in the "Objects" tab; display a graph of parameter changes - "Telemetry" (see Figure 4) and view the location of the UMD devices on the map in the "Transmitter Map".

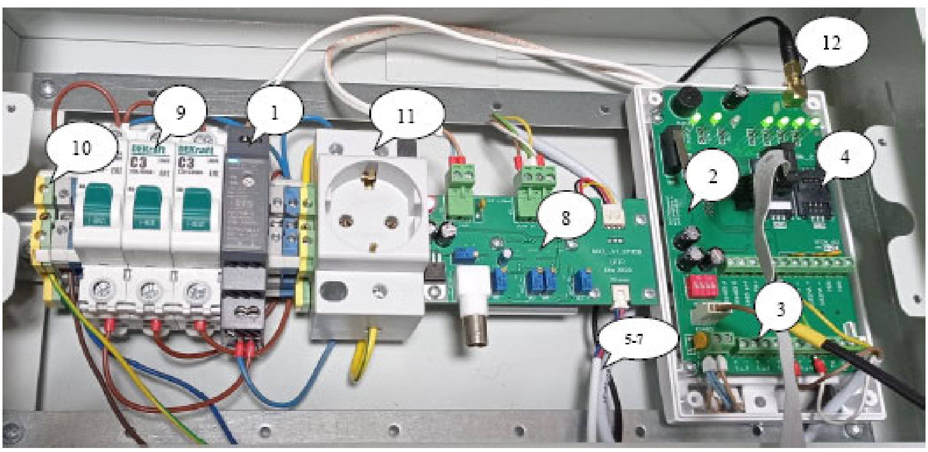


Fig. 2. View of the telemetry cabinet without a plug.

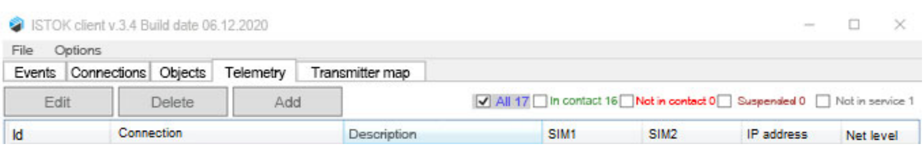


Fig. 3. The program interface.

Figure 4 shows graphs of changes in the main parameters in online mode. In addition, the software provides the possibility of constructing separate graphs according to parameters – levels in consumable tanks with a corrosion inhibitor (Figure 5), with a salt deposition inhibitor (Figure 6), electrical conductivity values (Figure 7), pH values (Figure 8).

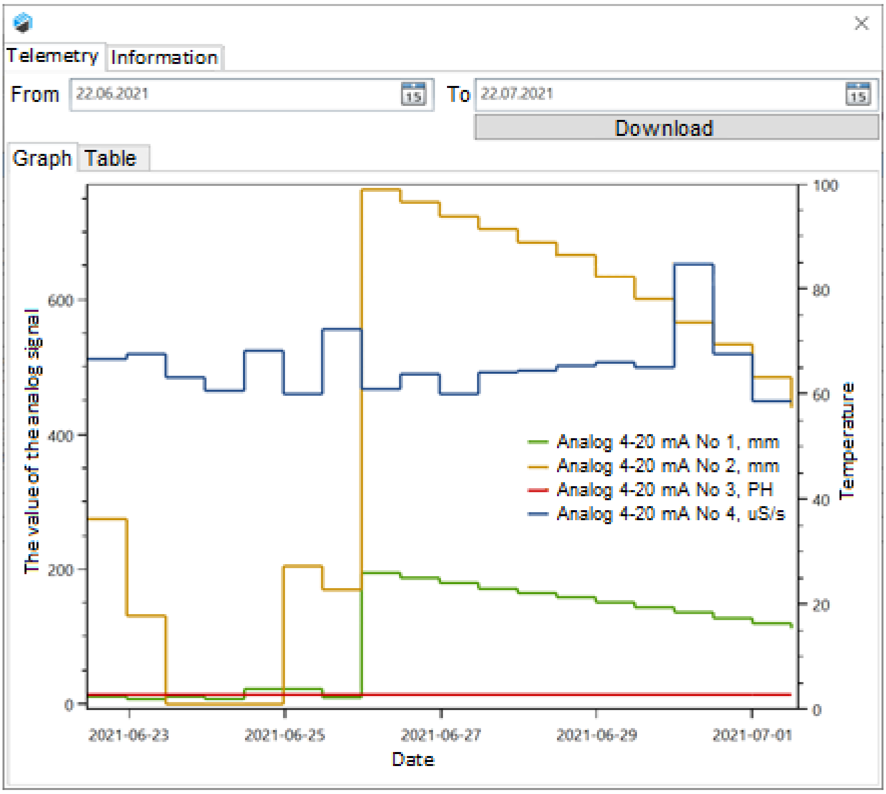


Fig. 4. The appearance of the client program in the graph view mode.

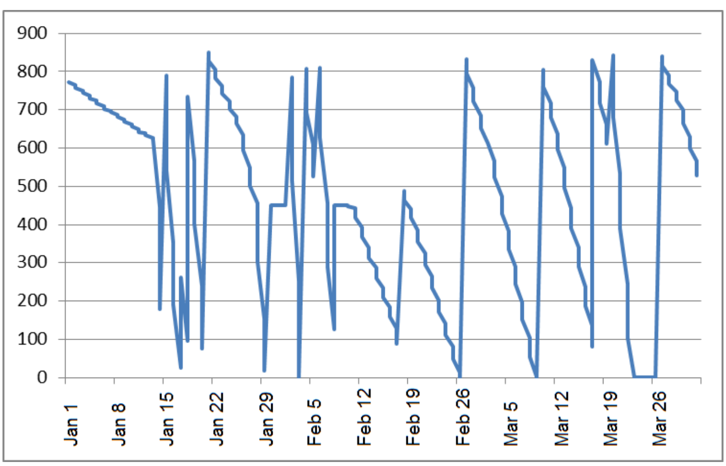


Fig. 5. Level in a consumable container with a corrosion inhibitor.

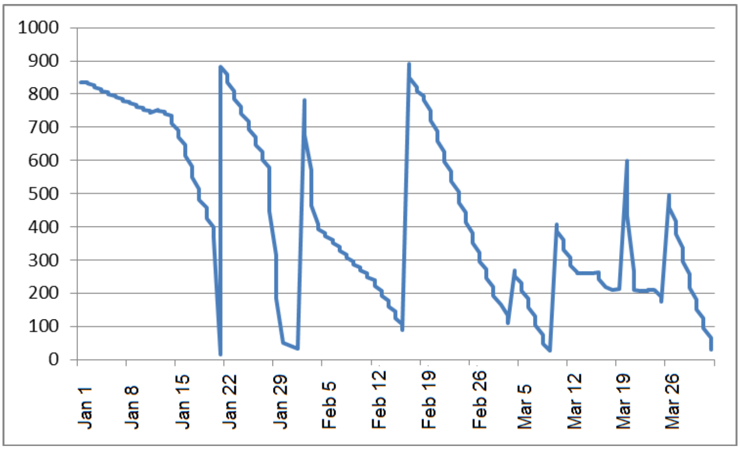


Fig. 6. Level in a flow container with a salt deposition inhibitor.

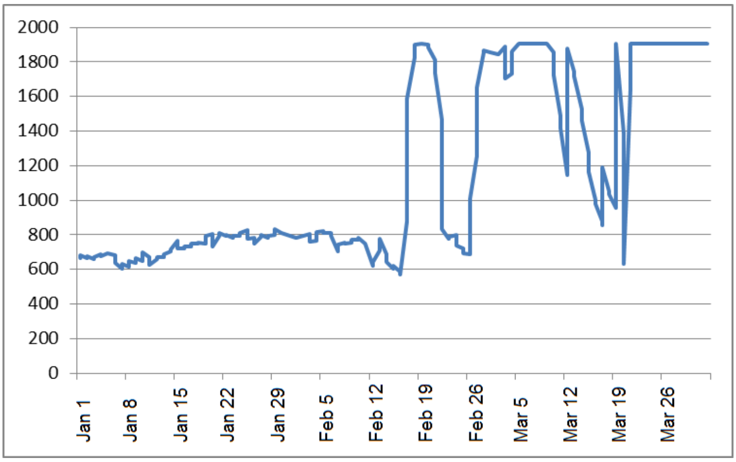


Fig. 7. Electrical conductivity values.

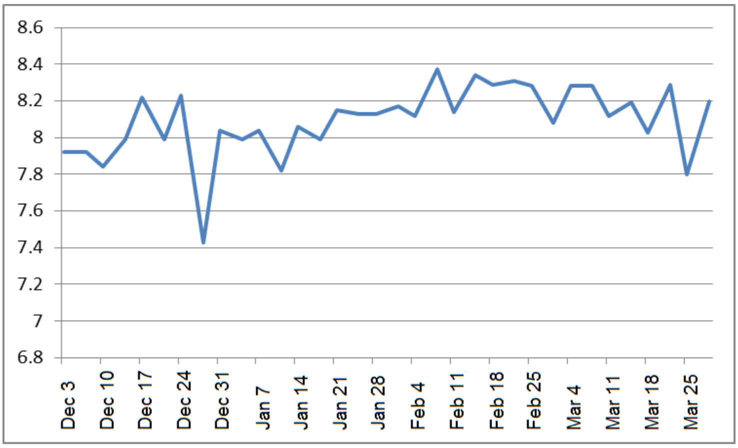
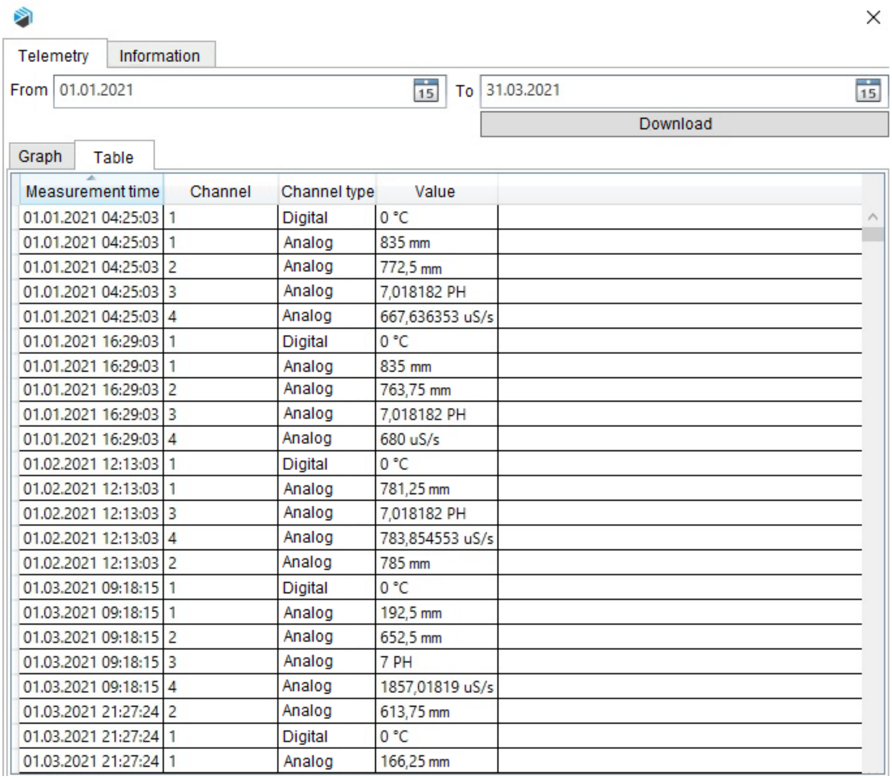


Fig. 8. pH values.



Measurement time	Channel	Channel type	Value
01.01.2021 04:25:03	1	Digital	0 °C
01.01.2021 04:25:03	1	Analog	835 mm
01.01.2021 04:25:03	2	Analog	772,5 mm
01.01.2021 04:25:03	3	Analog	7,018182 PH
01.01.2021 04:25:03	4	Analog	667,636353 uS/s
01.01.2021 16:29:03	1	Digital	0 °C
01.01.2021 16:29:03	1	Analog	835 mm
01.01.2021 16:29:03	2	Analog	763,75 mm
01.01.2021 16:29:03	3	Analog	7,018182 PH
01.01.2021 16:29:03	4	Analog	680 uS/s
01.02.2021 12:13:03	1	Digital	0 °C
01.02.2021 12:13:03	1	Analog	781,25 mm
01.02.2021 12:13:03	3	Analog	7,018182 PH
01.02.2021 12:13:03	4	Analog	783,854553 uS/s
01.02.2021 12:13:03	2	Analog	785 mm
01.03.2021 09:18:15	1	Digital	0 °C
01.03.2021 09:18:15	1	Analog	192,5 mm
01.03.2021 09:18:15	2	Analog	652,5 mm
01.03.2021 09:18:15	3	Analog	7 PH
01.03.2021 09:18:15	4	Analog	1857,01819 uS/s
01.03.2021 21:27:24	2	Analog	613,75 mm
01.03.2021 21:27:24	1	Digital	0 °C
01.03.2021 21:27:24	1	Analog	166,25 mm

Fig. 9. The appearance of the client program in tabular data viewing mode.

In the tabular data viewing format (Figure 9), each sensor is assigned a channel number: 1 and 2 - reagent level sensors in containers, 3 – pH sensor, 4 – electrical conductivity sensor. The user has the ability to sort data by all four parameters of the sensor breakdown: date of measurement, channel number, channel type, indicator value.

The Information tab (Figure 10) shows all the parameters of the controller (communication status, assigned id, operator and ID of the connected sim card, frequency of data editing, etc.). Color indication in the parameters communication status, transmitter tamper, 220 network monitoring and sensor power monitoring, allow you to timely find out about problems in the cabinet telemetry and eliminate them as soon as possible.

Monitoring using the UMD system made it possible to remotely monitor the consumption of reagents in tanks, changes in the electrical conductivity of water and pH in online mode. Figure 5 shows that the level in the tanks and, accordingly, the amount of the dosed corrosion inhibitor was significantly higher. This is due to the high rate of corrosion of the samples from Article 3 and the need to saturate the water circulation system with a corrosion inhibitor. But with a low level of salinity (Figure 7) and a low coefficient of evaporation of the corrosion inhibitor, even at such dosages, it was not enough. Figure 7 shows that the salinity of water changed significantly after February 12 and despite an increase in the amount of salts and corrosive chlorides, the corrosion rate decreased (Figure 11), that is, the corrosion inhibitor with this evaporation coefficient, it began to linger in the recycled water system and was not diluted with fresh, inhibitor-free water.

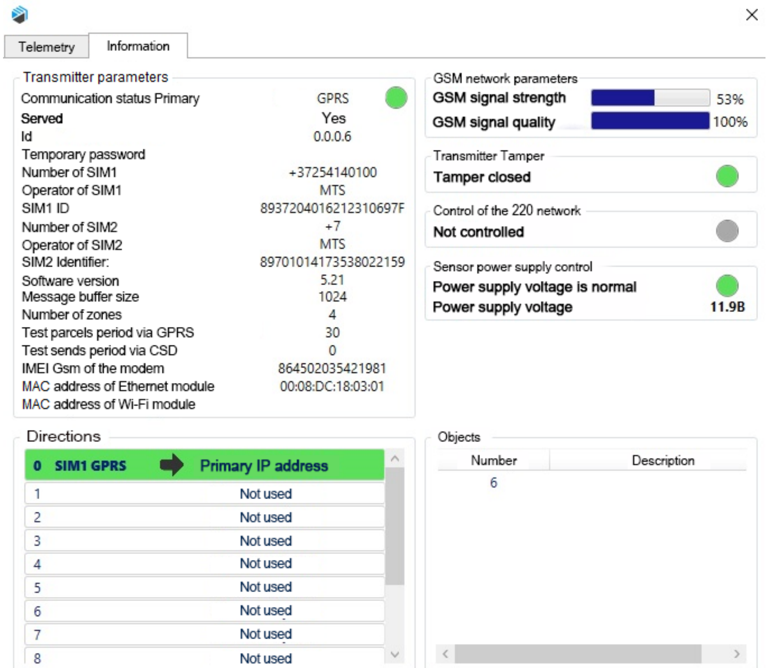


Fig. 10. Information window of a separate ISTOK 432-TM controller.

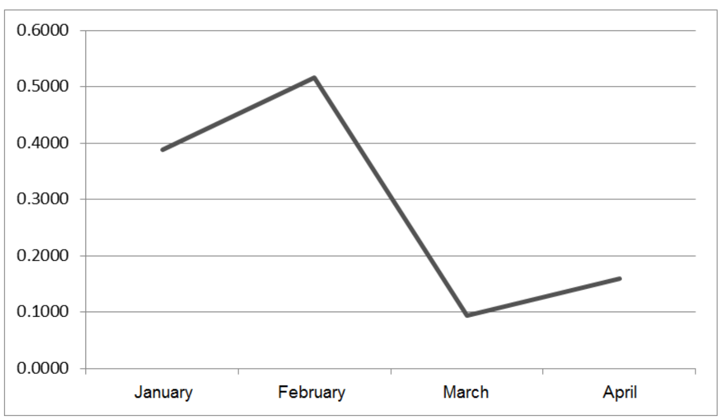


Fig. 11. Change in the corrosion rate of samples of St. 3 over time.

Timely adjustment of the reagent supply and monitoring of the supply modes using UMD made it possible to reduce the corrosion rate of St. 3 samples to the regulatory values within one month of processing - no more than 0.1 mm/year.

3 Conclusion

The UMD system allows you to constantly monitor the parameters of reagent water treatment and, with a minimum of data, ensure maximum reagent efficiency.

It is shown that in the conditions of a specific water circulation system, monitoring the composition of technological water for 1-2 months makes it possible to regulate the rate of corrosion and optimize it by varying the values of water parameters, that is, to prevent intensive corrosion of metal.

The UMD system for maintaining optimal parameters of process water for recycling water supply will significantly improve the safety of equipment and pipelines at oil refining enterprises.

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