SCADA СИСТЕМ ЗА НАДЗОР ВОДОВОДНЕ МРЕЖЕ У КРИВОЈ ПАЛАНЦИ

SCADA SYSTEM FOR MONITORING WATER SUPPLY NETWORK IN KRIVA PALANKA

ЦВЕТА МАРТИНОВСКА БАНДЕ[1], ЂОРЂИ БАНДЕ[2], ГОРЈАН БЛАЖЕВСКИ[3]

Резиме: У раду је претстављена студија за модернизацију водоводног система у Кривој Паланци, у Македонији. Као главне изворе воде систем користи изворе у месту Калин Камен, а алтернативни извори су Станечка река и четири бунара из басена Криве реке. Раст популације услед миграције из руралних подручја ка високим зонама града проузроковао је проблеме у водоснабдевању. Предложено решење за модернизацију система доприноси регуларном и континуалном обезбеђењу квалитетне питке воде. Поред тога, предлажемо имплементацију SCADA система за надзор и управљање параметрима у систему за диструбуцију воде.

Кључне речи: SCADA, систем водоснабдевања, аквизиција података, надзор, PLC.

Abstract: This paper presents a study for modernization of the water supply system in Kriva Palanka, Macedonia. As main water sources the system uses the springs of Kalin Kamen and the alternative sources are Stanechka reka and four wells in the basin of Kriva reka. The population growth due to the migration from rural areas into high zones of the city caused water supply problems. The proposed solution for modernization of the system contributes to regular and continuous supply of quality drinking water. Furthermore we propose implementation of SCADA system for monitoring and control of the parameters in water distribution system.

Key Words: SCADA, water supply system, data acquisition, monitoring, PLC.

1. Introduction

Modern Water Supply System (WSS) requires control, analysis and prompt response to events that reduce the effectiveness of the water supply or disrupt the functionality of the system. The technological advances in the field impose automated approach to solving these problems [1].

In literature a distinction is made between different Industrial Control Systems (ICT): Supervisory Control and Data Acquisition (SCADA), Distributed Control Systems (DCS) and Programmable Logic Controllers (PLC) [5]. SCADA systems are used for real-time acquisition of sensor data, monitoring equipment and

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[1] Цвета Мартиновска Банде, професор, дипл. ел. инж. Универзитет Гоце Делчев, ул. Крсте Мисирков, бр. 10 А, Штип, Македонија

[2] Ђорги Банде, дипл. инж. грађ. ROING, CES Saltzgitter, TUV Rheinland Dubai

[3] Горјан Блажевски, дипл. ел. инж. CES Saltzgitter

controlling processes in water distribution and wastewater collection systems, oil and gas pipelines, electrical power grid, etc [2, 3]. DCS are used to control production systems, while PLC for regulatory control. Within the last decade the security of the SCADA systems become important concern [4]. Initially, these control systems were isolated, using specialized hardware, software and protocols. Adopting information technology (IT) solutions for ICT, standard computers, low-cost Internet Protocol devices and network protocols contributed to connectivity and remote access capabilities. However, connecting the ICT systems to IT networks made them more vulnerable.

This paper presents a study for reconstruction of the water supply network in a small city located in eastern Macedonia, Kriva Palanka. Our aim is to create a SCADA system establishing a complete monitoring of the water supply network and thus allowing for quick and effective responses to alarming situations. The WSS for this city is interesting because there are three water sources which allow different configurations of the network. The main water sources for the city are springs in Kalin Kamen and alternative water supply options are Stanechka reka and four wells in the basin of Kriva reka. Furthermore, the disposition of the WSS is set on the both banks of the Kriva Reka, each of the banks having high and low zones, with seasonal and daily variations of the water requirements.

In this paper we propose architecture of a SCADA system for monitoring and control of the parameters in the WSS which will provide adequate functioning of the WSS, safety and efficient energy usage. SCADA system provides simple, fast and effective way of dealing with some situations and difficulties, such as natural disasters and their consequences, mechanical damages to the system, water loss, power interruption and communication problems among SCADA components. Also this system enables efficient management of the values for previously defined variables, like pressure, water flow, level of water in reservoirs etc. Finally, it is helpful for preventing bio/chemical changes, such as increased presence of chlorine or other harmful materials in the water.

2. Structure of the WSS and the problems

The water supply system in Kriva Palanka relies on the intakes of water from the area called Kalin Kamen which is located about 20 km from the city [6]. From Kalin Kamen -through a pipeline- the water is carried to the spillway Crvena niva (Fig. 1). From that storage the water is distributed to the tank Baglak 3, located at the high area of the Kriva reka right bank, and to the water fabrication plant. At the plant there is a water tank of 150 m^3 and the distribution shaft. Part of the water supply system is still under construction: the inflow of Stanechka reka that serves as a supplement to the WSS, the water supply line for high zone on the left bank of Kriva reka and the reservoir of 350 m^3 in district Martinica.

From the water fabrication plant the WSS continues to the chlorine station and the two main water tanks as well as to the distribution shaft used for water supplying of the low zone of the Kriva Reka, left and right bank. An additional spare water source from the wells in the region of Kriva reka is connected at the chlorine station. The water from these wells is pumped with pumps from 635 m asl to the chlorine station.

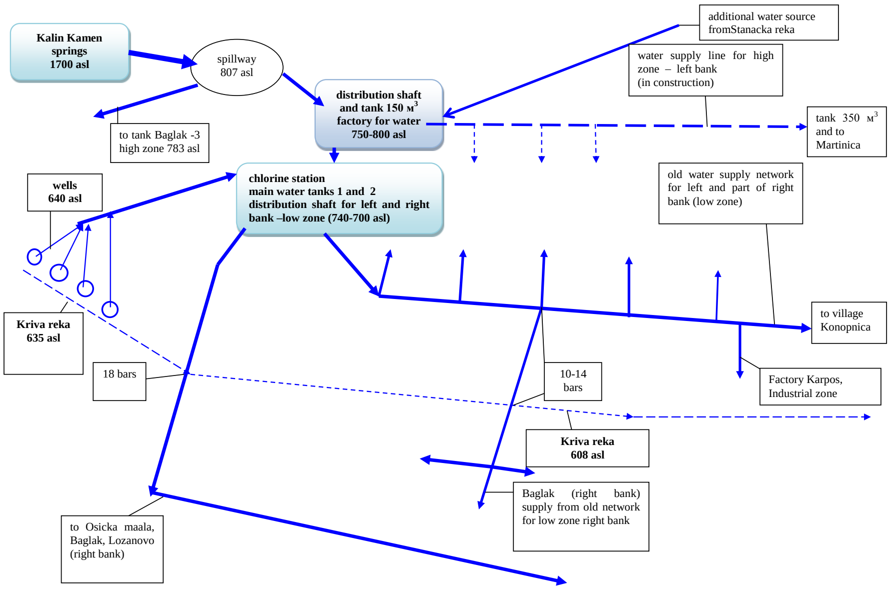

Fig. 1 Global scheme of Kriva Palanka WSS

The two main tanks of 250 m3 are used for the low zones of Kriva reka left and right bank. Currently, the high zone of Kriva reka left bank, the industrial zone and the village Konopnica are also supplied with water from these two main tanks.

The rapid populating of the high zones of the city caused problems with the water supply and also led to defects and failures in the city network, resulting with restrictions in the water supply, particularly in the high areas. Also, there are periods when -due to irrigation in the lower parts or even during the peak of water consumption- the water cannot reach the high areas. To overcome these problems and to bring the water in the higher parts, higher water pressure is used in the lower parts of the system which causes huge losses within the system.

The permanent water shortage and the returning of water from the higher parts, because of the high pressure, causes creation of so-called "air bags". This is the reason for the white color of the water, which creates an image of poor quality. Consumers believe that the water is too chlorinated because of the coloration and this affects the water consumption. The changes of the pressure in the network cause frequent failures.

3. Specifications of functional design for the SCADA system

In the first stage the SCADA system comprises monitoring, alarming and reporting functions for WSS, like monitoring the levels in reservoirs, flows and pressures on the outlets of production pump stations and water distribution reservoirs, control of the chlorinating process etc. The second stage will comprise manual/automatic operation of the WSS.

The control system is organized in a hierarchical structure with three layers (Fig. 2). The first layer consists of field instruments, remote terminal units (RTU), field control devices and control wiring. Field instruments, such as electromagnetic flow meters, ultrasonic level meters, actuators and flow, level, pressure, torque and limit switches are located at the measuring points on pipelines, water channels, tanks and pump station. The signals from instruments via transmitters are sent to dedicated PLC panels at the second layer. The operators can monitor the process at the PLC display and set or adjust the process parameters according to the process conditions at the moment.

RTUs are used for monitoring the water level of the remote reservoirs/tanks. Programmable data loggers with small capacity are used as RTUs. Analog or digital data are logged and send by radio/ WiFi network to PLC panels or SCADA center. Four types of field control devices are used: electrical motors, open/close control valves, automatic control valves and chlorine dosing equipment.

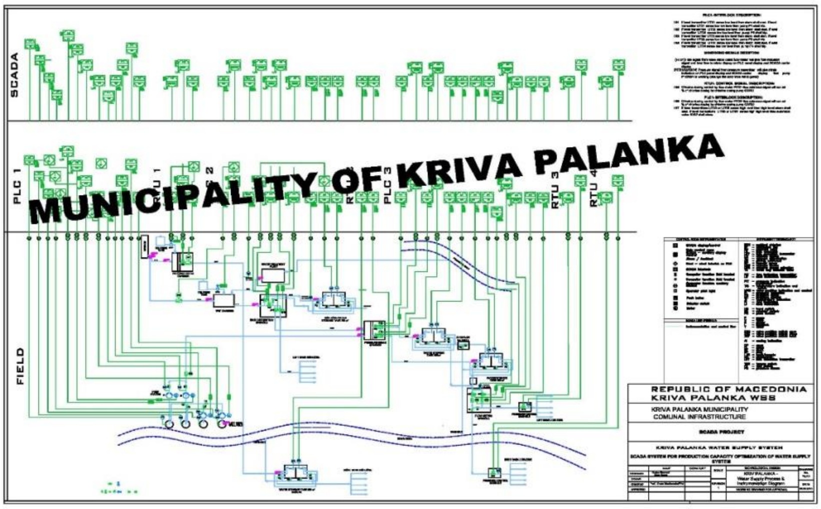

Fig. 2 SCADA system for production capacity optimization of WSS

The SCADA center is equipped with at least two servers, operator working station, and engineers workplace. The system has to provide efficient and safe operation of the process plant by detecting alarm and error conditions, visually and audibly alerting the operator, monitoring all important system parameters and has to provide advising strategy for system optimization. The system allows operators, technicians and engineers to issue commands to change system parameters, start and stop equipment, provide configuration tools and operate diagnostic facilities.

The new project for WSS in Kriva Palanka intakes the water from Kalin Kamen through F219 steel pipes to the location Crvena Niva. Another separation pipe F150 is set to the connector and chlorinating station through which the water is distributed to the tank. The tank is placed on the right bank of Kriva Reka for high zone Baglak 3 and is composed of two independent chambers. The plug at

Crvena Niva has a pressure break tank to reduce the hydrostatic pressure in the inlet pipeline.

In the pressure break tank are placed valves for manual water regulation for the high zone Baglak 3. The chlorination is done in the same tank with electromagnetic dosing pump. Two ultrasonic level transmitters are incorporated in the Baglak 3 zone tank, for both chambers. This system will provide automatic regulation of the water level in the Baglak 3 tank and will prevent unnecessary overflow, i.e. loss of water. Electromagnetic flowmeter will be installed in the same shaft. It will control the dosage of chlorine in the WSS for Baglak 3 and will give a control signal to chlorine dosing pump. The F219 pipeline continues to the main distribution shaft, located to the filter station at 780 meters asl. Before the main distribution shaft, the pipeline first enters the chlorination prechamber, in which the water comes from the Stanechka reka passing previously through the filtering station. As surface water it must be filtered and also chlorinated in the filtering station.

The flowmeter must be installed for proper chlorination, before the chlorination prechamber. It will provide a control signal to the chlorine dosing pump. The residual chlorine is monitored by two residual chlorine transmitters. One located before the tank, for the left bank of the high zone and the other located in the measuring shaft after the tanks, for the low zones of both banks. From the chlorination prechamber, a F300 pipe conveys the water to the main distribution shaft set before the water tank. From this shaft equipped with 4 manual valves the water is transferred to a 150 m3 tank for the left bank in the high zone, or directly into the distribution network for the left bank in the high zone and to the two tanks of 500 m^3 for the left and right bank for the low zones. The water from the main distribution shaft is distributed through the automatic valve AV04 in the distribution shaft for the left and right bank in the low zone, which is set at 730 m asl. The water from the wells of Kriva Reka, which are located at 640m asl, is supplied in this shaft. Because of the height differences, the water from the wells must be pumped with high pressure pumps to the distribution shaft for the low zone.

The field of Kriva reka has 4 wells. Two of these wells work as wells, and also as collector tanks in which the water from the other two wells is pumped using small pumps from 5 KW. The water from the main wells is pumped to the distribution shaft for low zone, with larger, high pressure 17.5 KW pumps. All wells are equipped with the level transmitters. Level transmitters provide a control signal to the corresponding pumps. The filtering station for the Suva reka’s water treatment is in its final phase of construction. A local PLC Panel will be built and will monitor the work of the filter station itself. After completing the construction and putting it into operation, a PLC panel will be connected via GPRS / GSM modem with the SCADA center.

4. Further development of the SCADA system

SCADA system is well known and implemented in the industry. SCADA applications via PLCs are designated to operate on certain, predefined scenarios, in which the limiting/ triggering parameters for particular actions are known in advance, just as the action schemes to be undertaken should a trigger occurs.

Initial triggering parameters for the PLCs to take action are based on knowledge and experience of the operating personnel. Meanwhile, a database is picking up the parameters from the PLCs and RTUs and creates a time-based history of the values. The results collected are analyzed through adequate algorithms using data mining techniques to create timed envelope values that are returned to the PLCs. Should an excess situation occurs, such as less water in the sources, defects within the network etc., an algorithm is activated to reconfigure the WSS network (PLCs parameters for the actuators, electric valves, shutters etc.). Once the situation is resolved/ stabilized (monitored by the sensors/ RTUs), the software returns the regular control to the automatics.

The system also controls the manual override on the pro-active units, so no unauthorized intrusions are allowed, unless approved by the operator (for technical maintenance, defects or such) which significantly increases the safety of the WSS against voluntary or hostile actions.

SCADA system also controls the quantity of the water supply, hence enabling the WSS companies to obtain adequate billing for the services rendered. This very point also allows the SCADA to locate defects within the network (loss of water, pressure) indicate and undertake adequate actions for the resolution of the problem.

5. Conclusion

The implementation of this project will significantly contribute to improving the standard of living of the local population, regular and continuous supply of quality drinking water and maintenance of the cleanliness and the hygiene to a higher level. The project will enable the further development of those parts of the city with intensive construction.

SCADA systems generally has a huge role and application in today's technology and they are making the process of control and automation of the systems significantly easier and more reliable.

6. References

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