CONTROL SYSTEM FOR MANAGEMENT OF WATER SUPPLY AT A FARM

Aleš Doležal

Bachelor Degree Programme (3.), Brno University of Technology, Czech Republic
E-mail: xdolez89@vutbr.cz

Abstract - This paper deals with installing a new system for the supply and management of water on a farm. A PLC from Unitronics company was chosen with the appropriate modules for control and operation. The PLC program has been written in the UniLogic integrated development environment from Unistronics company using ladder language. The new system is controlled and monitored locally by the HMI panel and remotely by the website. The HMI and the website were created in the UniLogic Integrated Development Environment. The thesis also deals with selecting suitable sensors and components for system regulation.

Keywords – PLC, Control system, flowmeter, level sensor

1. INTRODUCTION
Description of the old system
The control system for water supply and management, which is currently applied on the farm, is considered outdated from an economic and safety point of view and completely inadequate to current modern standards. At the time the system was designed and commissioned, it was one of the most advanced control systems on the market. However, the gradual advent of more modern and affordable technologies has made it obsolete. Therefore, farm owners have opted for investing in a control system that will already meet the requirements of modern times e.g. remote communication, diagnostics of equipment connected to the system. Furthermore, the system should not be demanding and costly to maintain and meet the safety requirements of today.

Figure 1: Block diagram of the old system
Concept of the new system
The system that will be installed in place of the existing system will work on a completely different principle of water supply to the farm. As this is not a retrofit of an existing system, the design can be implemented from scratch and does not have to follow the existing wiring. The newly installed system will meet the requirements of today's modern times, which present easier maintenance and operational requirements for the operator. The control system will be able to communicate with the operator remotely in the event of a fault, thus greatly reducing the time from fault onset to detection to fault clearance. Furthermore, the system will record operating conditions, according to which regular maintenance of the installed equipment can be planned. Last but not least, it will be possible to control and monitor the system remotely via a website.

![Figure 2: Block diagram of the new system](image)

2. SOLUTION

PLC
A PLC from Unitronics was selected to control the entire water supply system. The PLC was selected based on positive experiences in previous projects. Specifically, the B10-T42 model of the Unistream series was selected, this is the most advanced PLC that Unitronics supplies. The PLC also supports a Web server option for remote communication with the PLC via the Internet. Due to the lack of digital and analog inputs, the PLC has been supplemented with expansion modules, namely the UID-1600 and WCB2 modules. The UID-1600 module is used to expand the PLC with 16 more digital inputs. The WCB2 module is used to expand the PLC by two analog inputs and 10 digital inputs.

Flowmeter
An inductive flowmeter was chosen to measure the flow rate at the inlet pipe to the reservoir. The inductive flowmeter was chosen because of its low purchase price compared to other flowmeters that work on a different measuring principle (ultrasonic, turbine). Another reason why it was chosen is its design and method of flow measurement. There is no need for long stilling pipes etc.

Level gauge
A hydrostatic probe type level gauge was selected to measure the water level in the reservoir. The level gauge was selected based on the ease of installation in the reservoir and its purchase price. A two-state level sensor was selected as a backup level sensor in case of failure of the
hydrostatic probe. The hydrostatic probe measures continuously so that the actual level in the reservoir can be read.

**Control system**
The control system monitors the water level in the reservoir, from which the entire system is controlled. The system has created four virtual levels (level 1 - Water tank is full, level 2 - Water level in the water tank is decreasing, level 3 - Water level is low, level 4 - Water tank is empty). Based on these levels, controlled pumps are started to replenish the water in the reservoir, as well as the automatic pressure station (APS).

**Levels in the water reservoir**
The water is at level 1 in the reservoir. The booster pumps are off. When the water in the reservoir drops to level 2, the replenishment starts to bring the water in the reservoir to level 1. If the water intake from the water tank is greater than the inflow to the water tank and the water level drops to level 3, a text message is sent with a low-level message in the water tank. If the water level has dropped to level 4 i.e. the water tank is empty. The APS is switched off to avoid damage due to dry running and the pumps that replenish the water tank are still on.

**Additional pumps**
Additional pumps are located in wells around the farm. The pumps are controlled by a control circuit that communicates with the control system. In case of a request from the control system, the pumps are switched on. The pumps are equipped with several protection elements (current protection, phase failure control, and probes that monitor the water in the well). If the pumps are faulty, a fault message is sent to the control system and then a fault SMS is sent to the system operator.

**APS**
The APS ensures constant pressure in the farm's water supply system. The APS controls itself according to the current pressure in the line, when the pressure drops and there is enough water in the water tank the APS starts, if the APS does not start even if there is enough water in the water tank a fault SMS is sent.

**Controls**
The switch cabinet includes an HMI module that can be used to control and monitor the entire system. The HMI panel shows the current values of the system (outlet pressure, water level in the reservoir, faults on the equipment, etc.) To simplify operation and work on the equipment, remote access via the Internet has been established. The control and monitoring environments are identical both on the HMI panel and on the remote access via the website.

**Control algorithm**

**Automatic switching on of the additional pump in the well.**

![Figure 3: Automatic switching on of the additional pump in the well](image)

If the following conditions are met and the water in the well drops to the 2nd level, the pump switches on.

- pom filtr s1 - if the filter on the supply pipe is not blocked the pump can pump
aut c1 - the switch on the switchboard door must be switched to the AUT position
aut obr1 - automatic mode must be selected on the HMI and the AUT field marked
hladina s1 - there must be sufficient water in the well
vypadek faze s1 - the pump must not be powered by 2 phases
tepelná ochrana s1 - if the pump starts to overheat the system will switch off the pump

Switch off the additional pump by the probe in the water tank

Figure 4: Switch off the additional pump by the probe in the water tank

If the level in the water tank is higher than 1900 mm the pumps in the wells will switch off.

Pump motor hours counter

Figure 5: Pump motor hours counter

While the pump "c1" is switched on the Timer Accumulated counts for 1 hour, once the time is up the timer is reset and the counter is incremented by 1.

Probe failure in the water tank.

Figure 6: Probe failure in the water tank

If the probe in the water tank starts to send values out of range this condition is evaluated as a fault, the probe is disconnected and goes into semi-automatic mode. Information about the level is obtained from the float, which is located in the water tank. When a fault occurs, an SMS is sent to the system operator. The fault is displayed on the HMI as a red rectangle instead of a graphical display of the current level in the water tank.

3. CONCLUSION

The old system has been successfully upgraded to a newer and more advanced system that already meets the requirements of modern times and modern farms. Remote access has been very well received by the system operators. In the future, the new system should be complemented by sending a regular report for the past month with operational data.