Problems and advantages of SCADA systems when performing measurements at hazardous production technologies

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Abstract. Currently, much attention is paid by science and technology to remote control of hazardous production processes. One of the monitoring tools is the SCADA system, which allows you to evaluate the readings of measuring transducers and promptly report their critical changes to the operator. Of course, this system has certain disadvantages along with its efficiency and high functionality - first of all, the lack of basic methods for checking the system as a whole, evaluating the error, and evaluating the results of the values given. If we think from the standpoint of digitalization, SCADA is an intellectual double, an artificial intelligence that allows us to implement the basic principles of the 4th industrial revolution. The advantages and disadvantages of such systems will be discussed in this study.

1. Development of SCADA – system

In the modern world of Autonomous technologies, a stable process of self-testing of the system is extremely important.

In previous SCADA systems used in water supply and wastewater treatment plants, leased telephone pairs were used, one pair per signal / alarm. However, connecting telephone lines to remote stations was expensive, and rents were high, and telecommunications companies were reluctant to fix individual connections in their switches. This encouraged SCADA operators to look for other solutions. In the 1970s, many people tried to switch to radio communication and immediately faced a number of problems: the frequency bands were much narrower than at the beginning of the XXI century, and the rules for licensing frequencies in cities around the world were such that they often turned SCADA-based radio systems into a pipe dream [1].

The situation became easier after the transition from analog telemetry, which operates on the principle of frequency Shift Keying (FSK), to digital telemetry began in the 70 years of the last century. The first digital solutions were private companies, then there were systems based on COTS products (Commercial Off the Shelf/ ready-made commercial products from the shelf). Microprocessors combined with NASA’s compression and encoding technologies (the Bose-Chowdhury method, etc.) allowed multiple alarms and analog values to be transmitted on a single radio frequency (or on a single leased line in cases where radio could not be used).

In the end, SCADA systems began to give their users what they always dreamed of: up-to-date information about what is happening throughout the enterprise, plus the ability to manage the entire enterprise from a single center. Yet the first digital solutions were not as reliable as relays connected to a single FSK channel. SCADA systems with radio communication were periodically unavailable,
which could be due to a variety of reasons, including solar flares. Leased phone lines were also not a panacea: they could be broken by builders. And printed circuit boards forty years ago were not as reliable as they are today - component failures and design errors were commonplace.

On the example of technological chains of equipment that operates independently, a number of machines and mechanisms are monitored every minute through a network of sensors that measure several important factors online, such as vibration, electricity surges, and the uniformity of flow through the pipeline. This method of Informatization of measurements is both a means of saving money due to the deserted assessment technology, and a means of increasing the speed of reaction to a breakdown or emergency condition of equipment. The article deals with the issue of creating a system of level gauges and temperature monitoring devices on the example of a remotely operating pumping station [2,3].

SCADA-system is a tool program that provides creation of software for automation of control and process control in real time. Main tasks of the SCADA system:

- Collecting data from sensors and presenting it to the operator in a convenient way, including graphs of changes in parameters over time;
- Remote control of actuators;
- Entering tasks for automatic control algorithms.

Monitoring and management is exactly what the management system is installed for. Archives of parameters, messages, and reports are necessary for evaluating and analyzing the technological process, operator actions, and so on. One of the basic SCADA tools is also important for them – delineating access rights to management by levels (operator, technologist, and control system engineer).

![Figure 1. Example of SCADA system level 1.](image)

Due to the trend towards integration of process control systems and enterprise management systems, it is increasingly necessary to use SCADA as a data source for higher-level systems (figure 1). Some scads can act both as a server for consolidating all technological data and as a server for generating reports based on this data.

2. Development of an automated control environment for a hazardous production facility
The SCADA system cannot be represented without parallel systems that allow correlating sensor monitoring with financial management systems, security management systems, and enterprise
integrated development management systems. Thus, there is a connected, unified pyramid of subsystems, in which SCADA is the Foundation (figure 2).

![Figure 2. Pyramid of measurement Informatization (SCADA level 2).](image)

In figure 2 – OLAP - online analytical processing, ERP - enterprise resource planning, MES - manufacturing execution system, SCADA - supervisory control and data acquisition [4]

Technological automation systems are usually divided into 3 levels: lower, middle, and upper. Above them is the level of production management in general. The lower level is the sensors and actuators themselves. Middle level - controllers. At the middle level, it happens:

- automatic generation and issuance of control actions on Executive mechanisms;
- exchange information with the top level.

- The upper level is the SCADA level. At this level, what happens is:
  - collection, processing and storage of information received at the middle level;
  - visualization of current and archived information in a convenient form for the operator (mnemonic diagrams, graphs, trends, message logs);
  - entering operator commands;
  - reporting on the results of the technological process;
  - exchange information with the top level.

The use of SCADA systems in power will reduce the time, labor, and the cost of implementing the control system and increases its reliability and makes maintenance easier thanks to convenient methods of development, lack of the necessary network settings or selection from a single server to run a distributed system simple and comprehensible Russian-language interface, detailed background material, a set of learning projects and training courses, remember all the individual settings, tooltips, control the validity of the input information. If you follow the subject area in which the SCADA system is taught in University education, then you can mention measurement Informatization. In this course, in the specialty “Metrology, standardization, certification”, students are given the opportunity to study and model such systems. In this study we give an example of modeling a pressure sensor in a pipeline [5,6].

2.1 Modeling a pressure sensor and level in tank in Lab View

At present, the Informatization of measurements is very relevant as devices of complex design that require complex calculations are becoming more and more. Informatization of measurements allows you to dramatically reduce the potential risk of an accident at the enterprise.
Pressure vessels are a type of equipment subject to checks by Rostecnadhodzor. Pressure vessels are monitored by monitoring a system of sensors located at a distance from the control panel. The main causes of pressure vessel accidents are:

- Significant excess pressure due to a faulty safety valve, process failure, ignition of oil vapors in air collectors, absence or malfunction of gearboxes.
- Failure or absence of safety devices with quick-release covers.
- Defects in the manufacture of vessels, during repair (welds).
- Overflow of vessels with liquefied gases.
- Violation of security rules.

Thus, the condition of the vessels must be monitored. In the event of cracks, swelling of the walls, gas or liquid passing through or sweating in the welds, failure or incompleteness of fasteners, covers and hatches, failure or absence of safety valves, thermometers, alarm devices, etc. the operation of vessels is not allowed in order to avoid the destruction of the body, pulling out the covers and hatches of the vessel and similar accidents.

Based on GOST 22520-85, MI 1997-89, the output signal of the sensor must be converted into a unit of pressure measurement using a secondary device, but when checking this device, the output signal must be calculated using formulas. Also, there may be several sensor data, which increases the time of verification. To simplify verification and reduce the time spent on calculations, an automated system was developed in the "LabVIEW" program.

In the LabVIEW software environment, it was possible to implement a mechanism for calculating the pipeline error in a virtual form (figure 3).

**Figure 3.** Block diagram for calculating the error of pressure gauges in virtual form.

![Figure 3. Block diagram for calculating the error of pressure gauges in virtual form.](image1)

**Figure 4.** Block diagram for calculating the error of pressure gauges in comfortable type for operator.

![Figure 4. Block diagram for calculating the error of pressure gauges in comfortable type for operator.](image2)
After modeling block-diagramm begin download program for registration of error. Figure 4 shows the screenshot.

After creating a tabular interface for registering data on errors when checking the pressure gauge, we will start modeling the system for visual control of the fuel level in the tank and its temperature. This visual control is very important because it can quickly show the operator the critical level and give an error signal (figures 5-7).

**Figure 5.** Screenshot of panel instruments for design level of oil in pipeline.

**Figure 6.** Screenshot of SCADA for measure level of oil in pipeline in operator screen. Normal value oil in tank.

To visualize the emergency situation, we will also add a flashing "danger" element that will help the operator make decisions about emergency stop of the pumping pump and calling the repair team (figure 7).

**Figure 7.** Screenshot of SCADA for measure level of oil in pipeline in operator screen. Danger value oil in tank.
This diagram shows the conversion of an analog current signal to a physical value and a comparison of the obtained physical value with the readings of an exemplary measuring instrument to calculate the reduced error. The received data is automatically entered in the table to assess the suitability of the SI for use by the verifier and further transfer of data to the verification Protocol. The conversion of an analog signal to a physical value is performed in accordance with GOST 22520-85, using the formula:

\[
\left( \frac{\Delta_p}{P_{\text{max}}} + \frac{\Delta_i}{I_{\text{max}} - I_0} \right) \cdot 100 \leq \alpha_p \cdot \gamma
\]  

Thus, the developed installation allows you to detect extreme positions of pressure gauges on the pipeline, which may cause the meter to fail to take into account the limit (emergency) pressure. Such an automatic system is able to warn about a potential accident at the enterprise [7,8,9].

2.2. Verification of SCADA systems

If in plant engineer-metrologist can verification SCADA system, it needs analyse official rools for verification procedure. In Techekspert database, searching information - GOST R 8.873-2014 State system for ensuring the unity of measurements (GSI). State verification scheme for technical systems and devices with measuring functions that measure the volume (quantity) of digital information (data) transmitted over the Internet and telephony channels. In addition, the official reference standard for information transmission, GET 200-2012. State primary standard for measuring the volume of digital information transmitted over the Internet and telephony channels (figure 8).

Figure 8. State primary standard for measuring the volume of digital information transmitted over the Internet and telephony channels.

The presented standard allows you to calibrate the SCADA system for measurements, but you need to understand that the calibration of this system must be carried out in a complex way, i.e. you need to calibrate separately both the measuring transducers and the measuring channel itself.

3. Conclusion

The use of SCADA systems in power will reduce the time, labor, and the cost of implementing the control system and increases its reliability and makes maintenance easier thanks to convenient methods of development, lack of the necessary network settings or selection from a single server to run a distributed system simple and comprehensible Russian-language interface, detailed background
material, a set of learning projects and training courses, remember all the individual settings, tooltips, control the validity of the input information [10,11]. However, the monitoring system's potential is currently being built up, the system is able to make decisions independently in unsafe working conditions, and the system is able to register violations on its own. It is necessary to set the self-adjustment and self-calibration mode, since an UN-calibrated system can independently initiate an accident that is dangerous for personnel.

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