American Research Journal of Mechanical Engineering and Automation

Volume 3, Issue 1, 1-5 Pages
Research Article | Open Access

Architecture of Telemetry Systems for Monitoring and Control of Main Gas Pipelines

Konokhov Andrey Vladimirovich

OOO OryxTech, Director of Key Accounts Department. Oil and Gas Sector, Moscow, Russia.

ABSTRACT

The architecture of telemetry systems for monitoring and controlling main gas pipelines is a comprehensive solution integrating various technological components to ensure the safety and efficiency of operation of gas transmission networks. The main tasks of these systems include remote monitoring of technological parameters, control of gas reduction processes, as well as automatic response to emergency situations. These systems provide continuous data collection, processing and transmission, which allows you to quickly respond to changes in the technological process. An important aspect is the integration of telemetry systems with enterprise management systems, including SCADA systems, which helps to improve overall productivity and reduce operating costs. In the context of increasing requirements for the reliability and safety of main gas pipelines, the development and implementation of modern telemetry technologies remains a key direction in ensuring the smooth and safe operation of the gas transportation infrastructure.

KEYWORDS: *Telemetry systems, main gas pipelines, remote monitoring, SCADA systems, gas pipeline management, automation, security, telemetry architecture, gas reduction, innovative technologies.*

INTRODUCTION

Modern main gas pipelines are complex technological systems, whose efficiency and reliability are critical to the uninterrupted supply of gas to large urban areas and industrial enterprises. With the increasing demand for energy resources and the expansion of gas transportation networks, there is a growing need to develop and implement highly efficient monitoring and control systems that ensure both operational safety and economic efficiency. Telemetry systems, integrating advanced data collection and transmission technologies, play a key role in achieving these objectives.

The relevance of this topic is driven by the increasing demands for the safety and reliability of main gas pipelines, as well as the necessity for automation and optimization of their management processes. The implementation of modern telemetry systems not only minimizes the risks of emergency situations but also significantly reduces operational costs, thereby ensuring the competitiveness of gas transportation companies in the global market.

The purpose of this article is to examine the architectures of telemetry systems used in the monitoring and management of main gas pipelines.

Key Components of Telemetry Systems

Effective management of gas distribution processes requires the implementation of automated systems that ensure the control and regulation of gas supply. These systems encompass both automated process control systems (APCS) and dispatch control systems (DCS). A crucial element of these systems is the gas pressure reduction stations (PRS), which are equipped with telemetry systems for remote monitoring of key operational parameters. PRSs are an integral part of the APCS and include telemechanics for controlling electrochemical protection (ECP) and valve units.

The telemetry system is designed to provide continuous remote monitoring of the technological parameters of remote facilities involved in the transportation and distribution of thermal energy carriers, including natural gas. Its primary function is to collect, record, and transmit data from sensors and peripheral devices to central computing systems (such as dispatch centers) using both wired and wireless communication channels.

This system allows for efficient real-time control of the operation and condition of technological equipment. It ensures the safe operation of gas distribution network facilities and enables remote control of various devices, such as electric drives and regulators. The prompt response to emergency situations facilitated by telemetry helps prevent potential incidents, including signaling unauthorized access to facilities [1].

An innovative advancement in telemetry systems is the introduction of an additional communication channel and automatic valves that allow for the remote shutdown of gas supply within seconds. Currently, such equipment is absent in many regions, making its implementation particularly relevant. In the event of a gas leak, the system immediately transmits a signal about excessive pressure in the pipeline, enabling the dispatcher to promptly shut off the gas supply. This prevents leaks and preserves the remaining gas in the pipes, which can be utilized until the repair team arrives [2].

According to reports from major domestic gas distribution companies, the transition to automated monitoring systems for gas transportation networks is expected to be completed by 2026. As part of these efforts, a new telemetry and corrosion monitoring system is being developed. In the segment of electrochemical protection, the development of a new product—a potential measurement unit for the cathodic protection of pipelines—has been completed.

Moreover, in 2023, the revenue of one of the industrial holdings operating in this field increased by 11% compared to the previous year, reaching 17.3 billion rubles. A particularly significant growth was recorded in the "Electrical Engineering Instrumentation" segment, where revenue increased by 46%, amounting to 13.3 billion rubles. This holding includes six plants employing about 4,000 workers [3].

Architectural Approaches to Telemetry System Design

Telemetry systems on main gas pipelines are a complex combination of hardware and software tools designed for remote monitoring and control of pipeline parameters. These systems typically include a distributed network of sensors that collect real-time data on pressure, temperature, flow rate, and other parameters. The collected data is transmitted to centralized control centers, where it is analyzed and used for decision-making in operational management and emergency forecasting. The architecture of such systems must be scalable to account for the length of the pipelines and highly resilient to failures, achieved by using redundant communication channels and duplicating key system components. Below in Figure 1, the components of telemetry systems in main gas pipelines will be described.

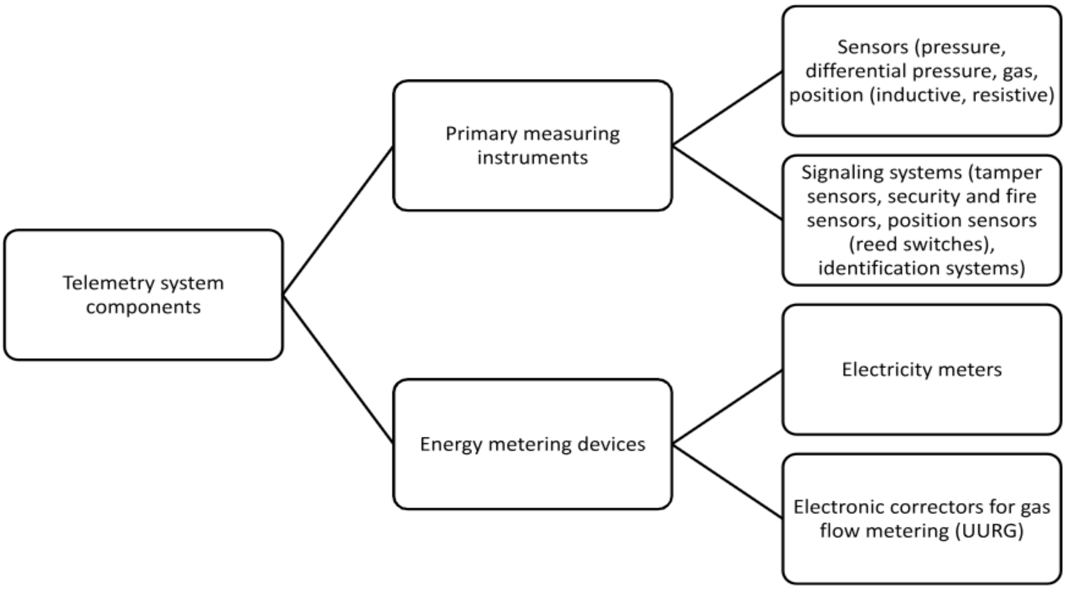

Fig.1. Components of telemetry systems in main gas pipelines [4].

When it comes to data transmission channels, they must meet several criteria, including operation via the GSM/GPRS protocol, the creation of a unified network for all system objects, and the ability to transmit data over the Internet. For the upper level of the system, an important criterion is the integration of software packages based on SCADA and modern programming languages. This will enable the creation of an interface that provides dispatchers with a visual display of information and allows for real-time emergency response, significantly enhancing the overall efficiency of the system [5].

Organizing effective data transmission channels under such conditions requires a specialized approach. Additionally, reliable voice communication between the dispatcher at the compressor station (CS) and the operator at the gas distribution station (GDS) must be ensured. Previously, copper four-wire cables were widely used for voice communication purposes. In recent years, with the advancement of technology, specialized adapters have been employed for data transmission to technological facilities, allowing information to be transmitted at speeds of up to 2.4 kbps.

Although this speed is limited, it allows for solving the basic control tasks. However, the challenge arises when combining a single cable for both voice communication and real-time data transmission. To address this issue, several approaches exist: installing channel multiplexing equipment, laying additional cables, or using radio channels. Today, radio channels are becoming increasingly popular for both voice communication and data transmission.

For remote object management, master controllers are often used in combination with SCADA systems, which provide communication with remote objects via long-range radio modems or cable modems. In practice, adhering to this requirement can be challenging, as controllers of different objects may support different communication protocols. For instance, one controller may use the ModBus protocol, another the DNP3 protocol, and a third a unique "non-standard" protocol. These differences create integration challenges when unifying various protocols into a single SCADA system, especially when using a shared radio channel. In such cases, channel multiplexing is required, which significantly increases the project's cost [6].

Thus, the communication and data transmission system serving such facilities faces the following tasks: wide coverage area, real-time data transmission capability between the master controller and remote controllers, organization of virtual buses for various protocols, provision of voice communication between the dispatcher and GDS operator, as well as voice communication for mobile subscribers.

Integration of Telemetry Systems with Management and Automation Systems

SCADA systems are designed to provide monitoring and centralized control of numerous remote facilities, which may be located at significant distances from each other, sometimes spanning thousands of kilometers. These systems play a crucial role in modern industrial processes by enabling the collection, processing, and analysis of data from various sensors and components, allowing operators to make informed and timely decisions.

When developing and configuring SCADA systems, it is important to consider their specific features. First and foremost is the use of specialized programming languages for developing control and management algorithms. Additionally, a key feature is the high speed of data processing and transmission, which ensures a timely response to changes in the technological process.

Moreover, SCADA systems allow for remote control and monitoring of processes. This enables operators to oversee and manage technological processes from any geographic location, which is particularly important for managing distributed facilities.

SCADA systems are also highly adaptable and can be customized to meet specific requirements. This adaptability allows the systems to adjust to diverse operating conditions and, if necessary, scale up to address more complex tasks.

SCADA software can be developed in various programming languages, such as C++, or created in specialized development environments. Additionally, SCADA systems are often supplemented with tools for programming controllers, which expands their functionality.

The security and reliability of SCADA systems are especially important in managing complex and critical processes. These automation systems have found widespread application in industries such as manufacturing, energy, space exploration, defense, and government administration. Comprehensive automated systems built on the basis of dispatch control significantly enhance the efficiency and safety of operations [7].

The primary challenges in organizing information exchange between different levels of corporate information systems (CIS) are related to the need for unifying and coordinating signals, logic, encodings, and states. These issues can arise both at the technological exchange level and at the business exchange level and are often associated with discrepancies in parameter naming, differences in data representation logic, or technical differences between systems from different manufacturers.

To address these issues, careful consideration of integration matters is required at the design stage. The introduction of parameter standardization and the unification of approaches to their processing can significantly ease the integration process and reduce the costs of system implementation and maintenance. For instance, when designing CIS, it is essential to clearly define the hierarchical place of each data source so that changes in equipment or its replacement do not require revisions of encodings and parameters.

Companies aiming to implement MES and ERP systems often encounter the challenge that their business processes do not align with the requirements of these standards. In such cases, the use of dispatch control systems (DCS) can fill the gaps in automation and integration across various management levels. These systems facilitate the collection, consolidation, and processing of data from multiple sources, as well as their transformation into a format suitable for loading into data warehouses or analytical systems.

Although DCS are not a universal solution, their implementation can significantly simplify the data integration process and improve enterprise management efficiency. This is especially relevant for companies that do not need the full functionality of ERP systems offered by giants like SAP or Oracle. The main task of DCS is to provide managers with access to consolidated information about the enterprise's activities in a clear and accessible form, making their implementation more straightforward and appealing.

Thus, the successful integration of SCADA systems with corporate information systems requires a comprehensive approach that includes both the selection of appropriate software and careful consideration during the design phase [8]. For greater clarity, the functionality of SCADA systems will be depicted in Figure 2.

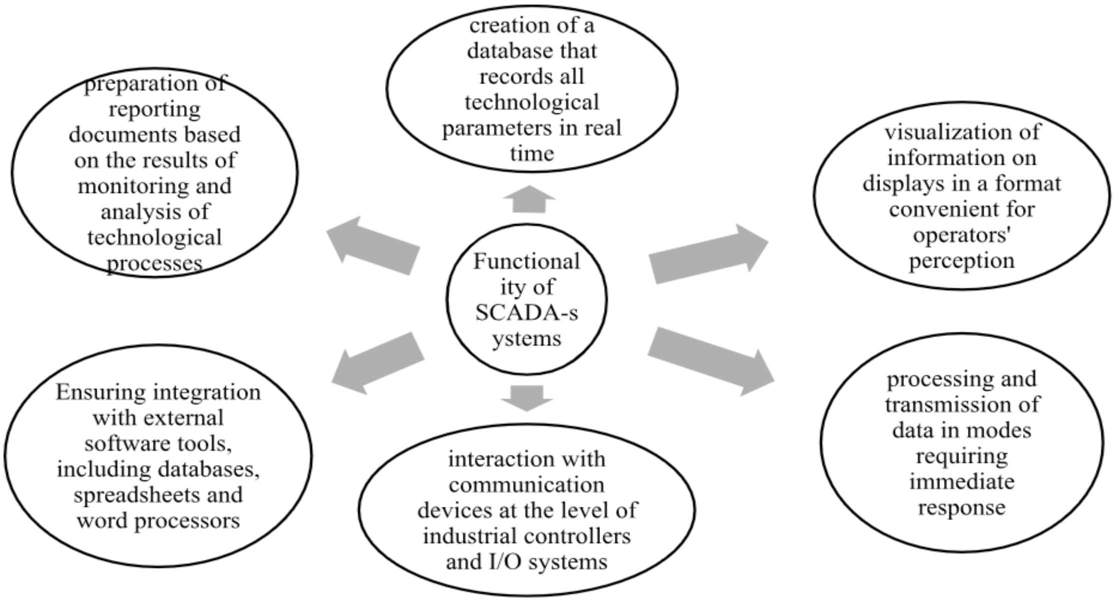

Fig.2. Functionality of SCADA systems [9].

Next, the advantages and disadvantages of SCADA systems will be presented (Table 1).

Table 1. Advantages and Disadvantages of SCADA Systems [10].

Advantages	**Disadvantages**
Increased production efficiency	Vulnerability to cyberattacks: SCADA systems can be susceptible to hacking, which may lead to data leaks, control blockages, sabotage, or even disruptions in pipeline operations.
Reduced labor and resource costs	Lack of protection in older systems: Many SCADA systems were developed before cyber threats became prevalent, and upgrading them for security can be challenging.
Improved product quality	Outdated equipment and software: SCADA systems may use hardware and software that are no longer supported by the manufacturer, creating issues when system upgrades or integration of new technologies are necessary.
Enhanced process safety	Need for regular training: Personnel must undergo regular training to maintain their skills in working with SCADA systems and to prevent errors.
Reduced equipment downtime	Cost of modernization: Upgrading SCADA systems, especially at large-scale facilities, can be very expensive.
	Maintenance costs: SCADA systems require regular maintenance and monitoring, which also involves financial costs and necessitates the availability of qualified specialists.

CONCLUSION

Thus, the efficiency and safety of main gas pipeline operations largely depend on the quality of telemetry systems. Proper architecture, integration with other automated systems, and the use of modern technologies not only ensure a high level of control and management but also significantly reduce the risks of emergency situations. The implementation of innovative solutions, such as automatic valves and additional communication channels, greatly enhances the system's ability to respond quickly to any changes in the pipeline's condition, thereby ensuring their reliable operation. Further research and development in the field of telemetry are essential for adapting systems to new challenges and safety requirements, confirming the relevance and promising nature of this direction.

REFERENCES

1. Telemetry system for gas distribution facilities. [Electronic resource] Access mode:https://gaz.ssoft24.com/upload/iblock/0db/l9wxb16kjrougxbsy0er601rvv9r1ugt.pdf (accessed 08/21/2024).
2. Vukolov V. A. Telemetry system on a gas pipeline // Bulletin of the Magistracy. – 2020. – №. 2-6 (101). – Pp. 19-20.
3. Energomera will develop a telemetry system for the gas transmission network in 2024. [Electronic resource] Access mode: https://tass.ru/ekonomika/21257523 (accessed 08/21/2024).

4. Alekseeva P. G. Analysis of telemetry data for predicting emergency situations at gas distribution and gas consumption facilities //Modern problems of ecology: reports of the XXV international scientific and practical conference under the general ed. VM Panarin.– Tula: Innovative technologies, 2020.-209 p. The collection contains materials on the problems of the state and assessment of the environmental situation, rational nature management, ecology. – 2020. – p. 188.

5. Borkova E. A. Digitalization, automation and data mining in the oil and gas industry //Technical and technological problems of the service. – 2021. – №. 4 (58). – Pp. 52-56.

6. Solutions for the organization of communication and data transmission on the linear part of the main gas pipelines. [Electronic resource] Access mode: https://www.fastwel.ru/solutions/resheniya-po-organizatsii-svyazi-i-peredache-dannykh-na-lineynoy-chasti-magistralnykh-gazoprovodov- / (accessed 08/21/2024).

7. Akimtsev A.V., Astapov V. N. Adaptive centralized control systems using SCADA systems. [Electronic resource] Access mode: https://scienceforum.ru/2022/article/2018028788 (accessed 08/21/2024).

8. Soldatov S. Integration of SCADA systems and enterprise management systems //Modern automation technologies. – 2016. – vol. 64. – No. 1. – pp. 90-95.

9. SCADA. [Electronic resource] Access mode:https://www.tadviser.ru/index.php/%D0%A1%D1%82%D0%B0%D1%82%D1%8C%D1%8F:SCADA_%D0%BD%D0%B0%D0%B7%D0%BD%D0%B0%D1%87%D0%B5%D0%BD%D0%B8%D0%B5_%D1%81%D0%B8%D1%81%D1%82%D0%B5%D0%BC (accessed 08/21/2024).

10. Kryukov V. V., Tugov V. V. Control of the gas reduction process in main gas pipelines //Bulletin of the Samara State Technical University. Series: Technical Sciences. – 2019. – №. 3 (63). – Pp. 35-46.

Citation: Konokhov Andrey Vladimirovich, "Architecture of Telemetry Systems for Monitoring and Control of Main Gas Pipelines", American Research Journal of Mechanical Engineering and Automation, Vol 3, no. 1, 2024, pp. 1-5.