Automation of monitoring and management of conveyor shop oil-pumping station of coal industry enterprise

V S Tynchenko[1,2]**, V V Kukartsev**[1,2]**, V V Tynchenko**[1,2]**, Chzhan E A**[1]**, Korpacheva L N**[1]

[1] Siberian Federal University, 79, Svobodny pr., Krasnoyarsk, 660041, Russia
[2] Siberian State University of Science and Technology, 31, Krasnoyarsky Rabochy Av., 660037 Krasnoyarsk, Russia

E-mail: vadimond@mail.ru

Abstract. The article deals with the problem of constructing an automated system for monitoring and controlling the oil-pumping station of a conveyor shop. Based on the analysis of the subject area, the shortcomings inherent in the work of the coal industry enterprise conveyor shop are revealed, and the automation tasks are set. The software is developed on the basis of the "GRANIT" telecommunication complex, intended for receiving and converting telemechanical information coming from controlled objects. As the hardware of the automation system, Siemens Simatic S7-400 controllers are selected, which ensure high reliability of the system and are widely used at Russian mining enterprises. As development tools, the SIMP Light environment for the implementation of the operator panel is used, as well as the programming language Pascal for writing scripts. Control in the automation system is realized through 6 channels, the main parameters of which are represented in the work. The application of the developed automation system allows operators to obtain the data of interest in numerical terms, to forecast emergency situations, and to track the elements of the system that initiated the failure.

1. Introduction

The coal industry plays an important role in the economy of any country. In Russia, one third of the world's coal resources and one-fifth of its reserves are concentrated, while coal is extracted by 121 slits and 85 mines. [1-3]

The main share of deliveries of mining enterprises falls to the following areas [4, 5]:

- Sales to wholesale consumers.
- Provision of population.
- Maintenance of power plants located in a small distance.
- Maintenance of own needs.

The problem of delivering products to power plants is solved through the design and construction of long conveyors directly from the face to the warehouse of the power plant. During the operation of the conveyor, constant lubrication of bearings is required, for which the oil-pumping stations (OPS) are used. [4, 5]

The oil-pumping station produces oil heating and its supply under pressure to the conveyor bearings. The main units of the OPS are:

- Tank.
- Pumping system.
- Electrical equipment.

Automation of monitoring and management of the OPS will ensure uninterrupted supply of lubricants to the conveyor elements, which will positively affect the reliability of equipment for transportation of coal products. Also, the introduction of an automated system will increase the qualitative and quantitative indicators of information collection from the OPS, which will lead to simplification of the monitoring and management processes. There is an opportunity for operators to get the data in numerical terms, predict emergency situations, determine the elements that caused this or that failure, and make decisions faster. [6]

2. Description of the research object

The object of the article research is the standard conveyor of the coal industry mining enterprise, consisting of the following elements: the tail part and the head part. To ensure uninterrupted lubrication of the conveyor bearings, an oil-pumping station is used, which has two tanks with oil and two engines: the main engine and backup ones. Each tank separately supplies oil according to the process: one tank delivers oil to the tail section of the conveyor, the other to the head.

Pressure control in tanks is carried out by pressure gauges. The oil station is controlled by relay units, in particular electromagnetic relays, designed to monitor the tail and overhead parts at the overload.

At present, the "GRANIT" telecommunication complex is widely used for transmitting, receiving, processing and displaying information in telemechanical automated process control systems. It combines two types of devices:

- Control points, where the microcomputer is embedded, providing software processing, receiving, transmitting and displaying information.
- Controlled items providing input, output, retransmission of heterogeneous information.

The complex "GRANIT" is executed on the trunk-module principle based on a limited set of functional elements with unified internal communications, regulated by the interface. The basis for the protocol for transmitting information over communication channels is the principle of time division and group transfer of information.

The basic software of the GRANIT telecommunication complex is designed for receiving and converting telemechanical information coming from monitored objects, transferring it to individual user programs and displaying it on boards.

Thus, the article proposes the creation of an automation system based on the "GRANIT" telecommunication complex using modern controllers, such as Siemens Simatic S7-400. This type of controllers was chosen due to, firstly, their wide distribution in enterprises, and secondly, their high reliability. [7 - 9]

3. Technological support of the automated system

The collection, transmission, processing and issuance of information is proposed to be carried out through sensors and controllers installed on the OPS, as well as the developed automated control system. [10]

This process will go through three levels:

1) The lower level is the sensors and actuators.
2) The middle level is the controllers. At this level:
   a) Reception of input data.
   b) Primary data processing.

    c) Automatic generation and delivery of control actions to actuators.

    d) Information exchange with the upper level.

3) The upper level is the SCADA level. At this level, there are:

    a) Collection, processing and storage of information received at middle level.

    b) Visualization of current and archival information in a convenient operator form (mnemonic diagrams, graphs, trends).

    c) Input of operator's commands.

    d) Automatic filling of the accounting log.

    e) Reporting on the results of the technological process.

4. Information support

In order to ensure the integrated automation of the monitoring and management process under consideration by the OPS, the intra-machine information support of the automated system should include:

- The accounting log (event log) which is a database containing all information about the accident, the time of its occurrence, its values.
- Screen form for output of effective information "Parameter list" that displays the names and values of the current active channels selected for monitoring and status monitoring.
- Screen form for outputting effective values "Channel list outside the setting range" that displays the channel values outside the specified acceptable limits.
- Screen form "Mnemonic diagram" which is a graphic representation of signaling devices and equipment images, as well as internal connections of the monitored channels (tags) of the OPC server.
- Screen form "View Graphs" that allows you to view graphs of the OPC server's channel values.

The links of the above program parts are implemented with the help of a script for analog and logical channels. Table 1 shows available channels, their type, communication with other channels, and visibility for the user.

Table 1. Virtual channels of the automation system.

Channel name	Type	Visibility	Connection	Script
Oil pressure	Analog	Yes	OPS work status, Enabled/disabled backup engine	Pascal Script
Oil temperature	Analog	Yes	Cooling	Pascal Script
Oil level in tank	Analog	Yes	None	Pascal Script
OPS work status	Logical	Yes	Oil pressure	None
Enabled/disabled backup engine	Logical	Yes	Oil pressure	None
Cooling	Logical	Yes	Oil temperature	None

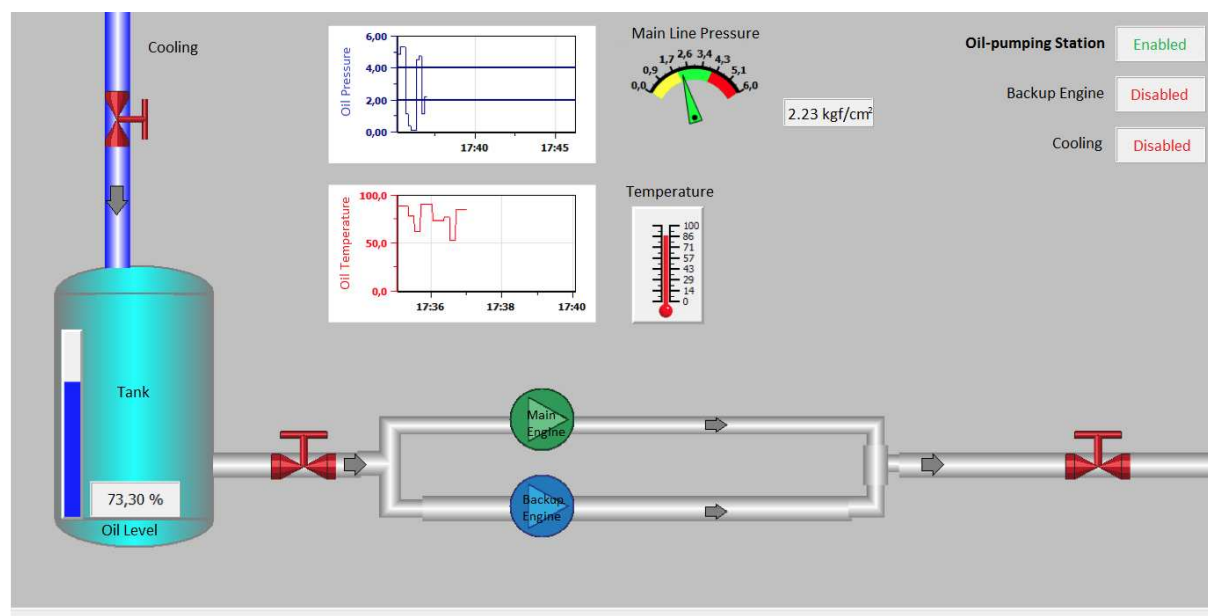Analog channels implemented in the system are presented in table 2.

Table 2. Analog channels of the automation system.

Channel name	Oil pressure	Oil temperature	Oil level in tank
Scale top	6,00	100,00	100,00
Scale bottom	0,00	0,00	1,00
Setting top	4,00	90,00	90,00
Setting bottom	2,00	60,00	1,00
Measured value	kgf/cm^2	Degrees Celsius	percents
Saving to database	Enabled	Enabled	Enabled
Variable type	Double	Double	Double
Polling interval, msec	10 000	10 000	1 000
Saving to database interval, msec	1 000	1 000	1 000

5. Automated system software

Automated monitoring and the management system of OPS was developed in the SIMP Light system. For writing scripts, the Pascal programming language was used.

The main window for working in an automated system is a monitor on which the mnemonic diagram of the oil-pumping station is depicted (Figure 1).

Figure 1. Mnemonic diagram of oil-pumping station.

The mnemonic diagram contains the following graphic components:

- The vertical capacity (tank).
- Oil main line (pipes).
- Valves.
- Engines (main and backup).
- Indicator for measuring the temperature of the oil in tank.

- Radial indicator for measuring main line pressure.
- Panels for displaying the pressure in the pipeline, the numerical value of the oil level in the tank, indicating the enabling/disabling of the OPS, the backup engine and cooling.
- Trends for displaying oil temperature and pressure charts.
- The oil level indicator in the tank.

6. Conclusion

As a result of the research and design work carried out, an automated information system for the monitoring and management of the oil-pumping station for the coal industry enterprise was implemented.

The using of such system will improve the quality and quantity of data collection from oil stations, which will simplify the process of monitoring and control. There will be an opportunity for operators to receive data in numerical terms, to forecast emergency situations, and to monitor the elements of the system that initiated the failure. All this will significantly improve the reliability of the transportation equipment and exclude interruptions in the supply of coal to consumers.

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